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TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 12

1976

HUBERT C. SKINNER
Editor

EMILY H. VOKES
Associate Editor

TULANE UNIVERSITY OF LOUISIANA
New Orleans

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY is devoted primarily to the geology and paleontology of the coasts and adjacent land areas of the Gulf of Mexico and the Caribbean Sea. Each number contains an individual monographic study, or several minor studies. As volumes are completed, title pages and tables of contents will be distributed to subscribers and institutions exchanging the entire series.

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* * *

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Tulane Studies in Geology and Paleontology
Earth Sciences Department
Tulane University
New Orleans, Louisiana 70118
U.S.A.

CONTENTS

VOLUME 12

NUMBER		PAGE
1.	THE GENUS *CONUS* (MOLLUSCA:GASTROPODA) FROM THE ALUM BLUFF GROUP OF NORTHWESTERN FLORIDA Shirley E. Hoerle	1
	A NEW SPECIES OF *CONUS* FROM THE CHIPOLA FORMATION Shirley E. Hoerle	31
	NOTES ON CANCELLARIIDAE (MOLLUSCA:GASTROPODA)—III Richard E. Petit	33
	A NEW PINECREST CANCELLARIID (MOLLUSCA:GASTROPODA) Richard E. Petit and Shirley E. Hoerle	44
	CENOZOIC MURICIDAE OF THE WESTERN ATLANTIC REGION, *DERMOMUREX*—ADDENDUM Emily H. Vokes	45
	A NEW SUBGENUS AND SPECIES OF *PETRICOLA* (MOLLUSCA:BIVALVIA) FROM THE PLIOCENE OF SOUTHERN FLORIDA Harold E. Vokes	47
2.	OSTRACODA FROM THE LOUISIANA CONTINENTAL SHELF Mervin Kontrovitz	49
3.	CENOZOIC MURICIDAE OF THE WESTERN ATLANTIC REGION, PART VII—*CALOTROPHON* AND *ATTILIOSA* Emily H. Vokes	101
	ON THE IDENTITY OF TWO SUPPOSED FASCIOLARIID GASTROPODS, *FUSUS MEXICANUS* REEVE, 1848, and *PERISTERNIA NODULOSA* A. ADAMS, 1855 Robert C. Bullock	133
	THE CRYSTAL RIVER FORMATION (EOCENE) AT MARTIN, MARION COUNTY, FLORIDA David Nicol, Graig D. Shaak and John W. Hoganson	137
	THE GENUS *VOORTHUYSENIELLA* (PROBLEMATICA) AT LITTLE STAVE CREEK, ALABAMA Drew Haman and Barry Kohl	145
	VOORTHUYSENIELLA (PROBLEMATICA) FROM THE PLEISTOCENE OF THE TEXAS CONTINENTAL SHELF Drew Haman and Barry Kohl	157
	NOTES ON THE FAUNA OF THE CHIPOLA FORMATION	
	XIX – ON THE PRESENCE OF *GASTROCHAENA (SPENGLERIA)* (MOLLUSCA: BIVALVIA) Harold E. Vokes	161

NUMBER PAGE

XX – A SECOND SPECIES OF *PETRICOLA (PETRICOXENICA)* (MOLLUSCA:BIVALVIA)
Harold E. Vokes 163

A NEW SPECIES OF *BUKRYASTER* FROM THE UPPER CRETACEOUS OF SOUTHEAST OKLAHOMA
Anthony Krancer 166

4. DINOFLAGELLATE TAXONOMY AND BIOSTRATIGRAPHY AT THE CRETACEOUS-TERTIARY BOUNDARY, ROUND BAY, MARYLAND
Don G. Benson, Jr. 169

EUTREPHOCERAS (NAUTILOIDEA) FROM THE PALEOCENE BEAUFORT FORMATION OF NORTH CAROLINA
Richard H. Bailey 235

CHARLES LYELL IN LOUISIANA
Hubert C. Skinner 243

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 12, Numbers 1, 2 May 27, 1976

Number 1

THE GENUS *CONUS* (MOLLUSCA: GASTROPODA) FROM THE ALUM BLUFF GROUP OF NORTHWESTERN FLORIDA
and
A NEW SPECIES OF *CONUS* FROM THE CHIPOLA FORMATION
SHIRLEY E. HOERLE
WEST PALM BEACH, FLORIDA p. 1

NOTES ON CANCELLARIIDAE (MOLLUSCA: GASTROPODA) – III
RICHARD E. PETIT
NORTH MYRTLE BEACH, SOUTH CAROLINA p. 31

A NEW PINECREST CANCELLARIID (MOLLUSCA: GASTROPODA)
RICHARD E. PETIT
NORTH MYRTLE BEACH, SOUTH CAROLINA
and
SHIRLEY E. HOERLE
WEST PALM BEACH, FLORIDA p. 33

CENOZOIC MURICIDAE OF THE WESTERN ATLANTIC REGION
DERMOMUREX–ADDENDUM
EMILY H. VOKES
TULANE UNIVERSITY p. 44

A NEW SUBGENUS AND SPECIES OF *PETRICOLA* (MOLLUSCA: BIVALVIA) FROM THE PLIOCENE OF SOUTHERN FLORIDA
HAROLD E. VOKES
TULANE UNIVERSITY p. 45

Number 2

OSTRACODA FROM THE LOUISIANA CONTINENTAL SHELF
MERVIN KONTROVITZ
RIDER COLLEGE, TRENTON, NEW JERSEY p. 47

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THE GENUS *CONUS* (MOLLUSCA: GASTROPODA) FROM THE ALUM BLUFF GROUP OF NORTHWESTERN FLORIDA

SHIRLEY E. HOERLE*

WEST PALM BEACH, FLORIDA

CONTENTS

Page

I. ABSTRACT 1
II. INTRODUCTION 1
III. ACKNOWLEDGMENTS 3
IV. SYSTEMATIC DESCRIPTIONS 3
V. LOCALITY DATA 29
VI. LITERATURE CITED 30

ILLUSTRATIONS

TABLE 1 4
TABLE 2 5
TABLE 3 6
PLATE 1 11
PLATE 2 15
PLATE 3 19
PLATE 4 23
PLATE 5 27

I. ABSTRACT

This study of the gastropod genus *Conus* comprises 24 species from the Alum Bluff Group of northwestern Florida, including 16 species from the Chipola Formation, late lower Miocene; four species from Oak Grove Sand, (?) late lower Miocene; and four species from the Shoal River Formation, middle Miocene. Eleven species are new: *C. aneuretos, C. ambonos, C. cracens, C. tapetus, C. erugatus, C. aquoreus, C. praecipuus, C. vegrandis, C. tricoratus, C. rapunculus* from the Chipola Formation and *C. drezi* from the Shoal River Formation. In addition, three homonyms are renamed: *C. gardnerae* for *C. corrugatus* Gardner *non* Sowerby; *C. vitius* for *C. fusiformis* Gardner *non* G. Fischer, *nec* Lamarck, *nec* Pease; *C. infulatus* for *C. turbinopsis* Gardner *non* Deshayes. All 24 species are treated systematically.

II. INTRODUCTION

The gastropod genus *Conus* Linné is primarily a Tertiary development, although a few ancestral forms likely occurred in late Cretaceous time. The group expanded rapidly in numbers and forms, becoming abundant during the Miocene epoch and reaching its greatest diversity in Recent time, particularly in the Indo-Pacific region. *Conus* is mainly a tropical genus with a varying

*Research Associate, Paleontological Research Institution, Ithaca, New York; Associate, Department of Earth Sciences, Tulane University.

EDITORIAL COMMITTEE FOR THIS PAPER:

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habitat, living on reefs, rocks, mud, or sand, from the inter-tidal zone to 100 fathoms. The exotic coloring of the Recent specimens of *Conus* led to numerous taxonomic designations by earlier European workers, many of them vying with each other to be the first to publish a particular species. Oftentimes the proper locality data were not designated and the haste of the authors resulted in a confusion of synonyms. Tomlin (1937) compiled an invaluable catalog listing over 2,700 species of *Conus* (both fossil and Recent) in which he attempted to determine the validity of the specific taxa, the original locality from which each species was collected, and the repository of the holotype, if known. This study revealed many instances of three or more different names assigned to the same species plus the fact that some type localities still remain in doubt.

A natural subdivision of the genus *Conus* with its multiplicity of species would be useful in classification, however, most of the proposals so far suggested have not met with general acceptance by most workers. Clench (1942, p. 36) stated, "The entire family of Conidae must be studied as a whole before any stability can be reached and the complex relationship worked out."

Color has long been a determining factor in the identification of *Conus.* Dall (1890, p. 27) noted that it was "almost impossible, without the color markings, to identify [fossil] cones; and therefore, identifications must always be taken as approximate." The color pattern and the degree of intensity of color do not necessarily signify a different species of *Conus.* These color factors may be merely an indication of an ecologic or genetic variance within the species. Von Linden (1896) and Burnett Smith (1929, 1945, 1946) pioneered a new approach to the recognition of species by using the characteristics of the early whorls as determining factors. Unfortunately their method was not adopted because workers found few unabraded specimens. With advanced techniques in obtaining Recent shells and an increase in the number of available fossil localities, better specimens are being collected. Van Mol, Tursch and Kempf (1967) in the "Resultats Scientifiques des Campagnes de la *Calypso* " advocate the same logical procedure for determination of species.

The present paper is concerned only with the members of the genus from the Miocene Alum Bluff Group of northwestern Florida. The species from the Chipola Formation far out-number those from either the Oak Grove Sand or the Shoal River Formation. Sixteen species occur in the Chipola fauna and only one of these, *C. cracens* n. sp., has a recognizable affiliation with a species of earlier age. Another new species, *C. praecipuus,* is considered ancestral to *C. consobrinus* common in the Miocene of Santo Domingo, Panamá, Mexico and Jamaica.* Of the 24 species of *Conus* studied in this paper, only one occurs in more than one formation, *C. gardnerae nom. nov.,* from both the Chipola Formation and the Oak Grove Sand.

During the course of this study, the writer examined nearly 25,000 specimens. The majority of the Chipola *Conus* are well preserved with perfect apical and spire whorls, thus facilitating their specific identification by the system used herein. Taxonomic determinations were based solely on morphological characteristics, such as the nuclei, early post-nuclear whorls, sutures, and anal fascioles. Regardless of the number of whorls comprising an adult specimen, the early whorls remain constant throughout life. As an example, if the first three or four post-nuclear whorls are beaded on a juvenile specimen it will retain the beading regardless of the size or number of whorls it acquires with maturity. Misleading factors in species identification are: the angle and height of the spire; the angle of the shoulder; the basal sculpture; and pustules on final whorl. These features oftentimes change with the growth of the shell.

The color pattern of several species, as revealed by ultraviolet light, has been figured. (For details of the process see Vokes and Vokes, 1968, p. 76.) These figures are not intended to be used as a means of identification but as an additional point of

*World-wide planktonic foraminiferal correlation indicates that some formations previously known as middle or upper Miocene are, in the planktonic chronology, middle Pliocene in age.

interest, noting that different species do have different color patterns. The Chipola *Conus*, with the exception of one species, *C. aneuretos*, all have a basic color pattern of interrupted spiral lines, overlain by either flammules, blotches or bands. Judging by the patterns shown with the aid of ultraviolet light it is evident that many of the cones from the Chipola fauna were exceedingly well-marked and colorful.

The 10,000+ *Conus* specimens in the writer's own collection were used as a basis for a study of the geographic distribution of the genus within the Chipola Formation. Approximately 70% of the specimens were collected from Ten Mile Creek, the remaining 30% nearly equally divided between the Chipola River and Farley Creek. Apparently the fine sandy clay of Ten Mile Creek and adjacent areas of the Chipola River were better suited for their habitat. On the other hand, some species are confined to the coral reefs and calcareous beds of Farley Creek and downstream portions of the Chipola River. Reef and rock dwellers as well as sand and mud dwellers occurred during Chipola time.

As there is no continuous section exposing the three Alum Bluff formations (Chipola, Oak Grove Sand and Shoal River) the exact stratigraphic relationship between the Chipola Formation and the Oak Grove Sand has not been clearly established. Later workers are generally agreed that the Oak Grove Sand is probably a facies of the Chipola Formation. This hypothesis is substantiated by the number of species common to both beds. However, the silty bottom of the Oak Grove sea provided a more favorable environment for pelecypods than for gastropods. Apparently there was a cooling of the waters during the Shoal River time, as the fauna loses some of the tropical aspects and is more comparable to that of temperate waters.

Only five of the 24 species of *Conus* reported in this paper occur in the Oak Grove, one of these, *C. gardnerae*, is also in the Chipola beds. Three of the above-mentioned five were named from single specimens. Four species have been collected from the Shoal River Formation and two of these are represented by single examples: only *C. waltonensis* is found in abundance. Apparently this one species evolved and thrived on a silty bottom.

The meager (compared to the Chipola fauna) representation of the genus *Conus* in the Shoal River fauna may reflect cooling of the waters during the later stage (Gardner, 1926, p. 2). The distribution of the genus *Conus* in Recent fauna demonstrates that, although a few species can tolerate temperate waters and some prefer subtropic waters, the majority are found in a tropical environment. Many more individuals are living in the tropical waters of the vast Indo-Pacific than in either the western Atlantic or eastern Pacific Provinces.

III. ACKNOWLEDGMENTS

The writer wishes to express appreciation to all those that made this study possible: Harold E. and Emily H. Vokes (Department of Geology, Tulane University) for their superb photographs and loan of Tulane University materials; Paul E. Drez, Chapel Hill, North Carolina, for the use of his personal collection and his contribution of a unique specimen; Druid Wilson and Thomas R. Waller (U. S. Geological Survey and Smithsonian Institution, respectively) for making the U. S. National Museum specimens available; and Katherine Van Winkle Palmer, Paleontological Research Institution, for providing type specimens for study.

Thanks are due the Editorial Committee for their time so willingly given and their constructive suggestions for the improvement of this paper.

IV. SYSTEMATIC DESCRIPTIONS

Phylum MOLLUSCA
Class GASTROPODA
Subclass PROSOBRANCHIA
Order NEOGASTROPODA
Suborder TOXOGLOSSA
Superfamily CONACEA
Family CONIDAE Rafinesque, 1815
Subfamily CONINAE Rafinesque, 1815
Genus CONUS Linné, 1758

Conus LINNÉ, 1758, Systema Naturae, 10th ed., p. 712. Type species: *Conus marmoreus* Linné by subsequent designation, Children, 1823.

TABLE 1. CHIPOLA FORMATION

SPECIES	NUCLEAR WHORLS	TELEO. WHORLS	SUTURES	ANAL FASCIOLE	SPIRE OUTLINE	BODY OUTLINE	BASAL SCULPTURE	REMARKS
C. chipolanus Dall	3¼ slender	9	adpressed	flat-concave	high, concave	slender, attenuated	wide bands and narrow grooves	first ¼ teleo. whorl with axial riblets
C. demiurgus Dall	2¼ bulbous	8	impressed	flat	flat-low	slender, flat-sided	unequal spiral threads, crowded, sinuous	large, slender; juv. nucleus with erect calcarella
C. isomitratus Dall	2 slender	8	impressed	convex	low, convex-str.	stubby	coarse, evenly spaced rounded cords	small, heavy
C. sulculus Dall	2½ slender	10	adpressed	concave	low, concave; apex elevated	gradually tapering	alternating in size sinuous threads	large; spire whorls threaded; granules basally on juv.
C. gardnerae nom. nov.	3½ slender, taper.	7	adpressed	flat-concave	high, concave	flat-sided tapered	bands and grooves	occasional pustules on spiral bands
C. trajectionis Maury	3½ slender, taper.	10	distinct adpressed	flat	low, straight-sided	pyriform	spiral threads rough-ened by growth lines	early whorls noded; spire whorls threaded
C. aneuretos n. sp.	3 slender	8	closely adpressed	concave	med. high, concave	broad, tapering	flat spiral bands, striated grooves	no spiral threading; occasional pustules on final whorl
C. ambonos n. sp.	3 tapering	8	adpressed	concave	low, concave	elongate, constricted	flattened spiral cords	elevated rimmed shoulder, 3 post-nuclear whorls axially costate
C. cracens n. sp.	3 slender	10	lightly adpressed	concave	low, concave	attenuated, constricted	incised lines separat-ing wide, flat bands	large, light weight; nodes, spiral threading, acute shoulder
C. tapetus n. sp.	1¾ broadly rounded	9	adpressed	flat	low, elevated apex	straight-sided	8-12 unequal, inequa-spaced cords, heavier on adapical edge	first 3-4 whorls beaded; spiral threading
C. erugatus n. sp.	1½ broadly rounded	8½	impressed	flat	low, elevated apex	flat-sided	coarse spiral threads	early whorls noded; one thread on spire whorls

C. aquoreus n. sp.	1¾ slender	9	lightly adpressed	flat-concave	flat, erect nucleus	elongate, slender, flat-sided	meager, irregularly spaced flattened cords on anterior fifth	weak spiral lineation on whorl summits
C. praecipuus n. sp.	unknown	9	closely adpressed	narrow, concave	high, flat-sided	tapering	cords over entire final whorl	spire whorls threaded, heavily tubercled
C. vegrandis n. sp.	2 rounded	7	lightly adpressed	flat-convex	mod. high	conic	heavy rounded cords, unevenly spaced	small; early whorls axially costate; shoulder cord; microscopic threading
C. tricoratus n. sp.	3 slender	7	adpressed	flat	high, concave	slender, attenuate	10 rounded spiral cords	first 4 whorls axially costate
C. rapunculus n. sp.	3½ tapering	8	adpressed	flat	conic	elongate, constricted	broad bands, narrow grooves	first 3 post-nuc. whorls axially costate; columella twisted; canal recurved

TABLE 2. OAK GROVE SAND

SPECIES	NUCLEAR WHORLS	TELEO. WHORLS	SUTURES	ANAL FASCIOLE	SPIRE OUTLINE	BODY OUTLINE	BASAL SCULPTURE	REMARKS
C. draperi Maury	unknown	8	lightly adpressed	flat	low, straight-sided	broad, gradually tapering	faint lines	large , heavy
C. nemorideditus Maury	unknown	8	adpressed	convex	mod. high, slightly convex	rounded shoulder, taper to base	raised threads	large, light weight
C. dodona Gardner	3 tapering	7	adpressed	concave	mod. low, concave	elongate, basally constricted	unequal and uneven spaced sinuous threads	heavy shell; rimmed shoulder
C. vitius nom. nov.	3½ tapering	6	distinct, slightly impressed	concave	high, straight-sided	slender, tapering	bands and grooves	small, slender, fusiform; bands and grooves cover final whorl

TABLE 1. CHIPOLA FORMATION

SPECIES	NUCLEAR WHORLS	TELEO. WHORLS	SUTURES	ANAL FASCIOLE	SPIRE OUTLINE	BODY OUTLINE	BASAL SCULPTURE	REMARKS
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C. demiurgus Dall	2¼ bulbous	8	impressed	flat	flat-low	slender, flat-sided	unequal spiral threads, crowded, sinuous	large, slender; juv. nucleus with erect calcarella
C. isomitratus Dall	2 slender	8	impressed	convex	low, convex-str.	stubby	coarse, evenly spaced rounded cords	small, heavy
C. sulculus Dall	2½ slender	10	adpressed	concave	low, concave; apex elevated	gradually tapering	alternating in size sinuous threads	large; spire whorls threaded; granules basally on juv.
C. gardnerae nom. nov.	3½ slender, taper.	7	adpressed	flat-concave	high, concave	flat-sided tapered	bands and grooves	occasional pustules on spiral bands
C. trajectionis Maury	3½ slender, taper.	10	distinct adpressed	flat	low, straight-sided	pyriform	spiral threads roughened by growth lines	early whorls noded; spire whorls threaded
C. aneuretos n. sp.	3 slender	8	closely adpressed	concave	med. high, concave	broad, tapering	flat spiral bands, striated grooves	no spiral threading; occasional pustules on final whorl
C. ambonos n. sp.	3 tapering	8	adpressed	concave	low, concave	elongate, constricted	flattened spiral cords	elevated rimmed shoulder, 3 post-nuclear whorls axially costate
C. cracens n. sp.	3 slender	10	lightly adpressed	concave	low, concave	attenuated, constricted	incised lines separating wide, flat bands	large, light weight; nodes, spiral threading, acute shoulder
C. tapetus n. sp.	1¾ broadly rounded	9	adpressed	flat	low, elevated apex	straight-sided	8-12 unequal, inequaspaced cords, heavier on adapical edge	first 3-4 whorls beaded; spiral threading
C. erugatus n. sp.	1½ broadly rounded	8½	impressed	flat	low, elevated apex	flat-sided	coarse spiral threads	early whorls noded; one thread on spire whorls
C. aquoreus n. sp.	1¾ slender	9	lightly adpressed	flat-concave	flat, erect nucleus	elongate, slender, flat-sided	meager, irregularly spaced flattened cords on anterior fifth	weak spiral lineation on whorl summits
C. praecipuus n. sp.	unknown	9	closely adpressed	narrow, concave	high, flat-sided	tapering	cords over entire final whorl	spire whorls threaded, heavily tubercled
C. vegrandis n. sp.	2 rounded	7	lightly adpressed	flat-convex	mod. high	conic	heavy rounded cords, unevenly spaced	small; early whorls axially costate; shoulder cord; microscopic threading
C. tricoratus n. sp.	3 slender	7	adpressed	flat	high, concave	slender, attenuate	10 rounded spiral cords	first 4 whorls axially costate
C. rapunculus n. sp.	3½ tapering	8	adpressed	flat	conic	elongate, constricted	broad bands, narrow grooves	first 3 post-nuc. whorls axially costate; columella twisted; canal recurved

TABLE 2. OAK GROVE SAND

SPECIES	NUCLEAR WHORLS	TELEO. WHORLS	SUTURES	ANAL FASCIOLE	SPIRE OUTLINE	BODY OUTLINE	BASAL SCULPTURE	REMARKS
C. draperi Maury	unknown	8	lightly adpressed	flat	low, straight-sided	broad, gradually tapering	faint lines	large , heavy
C. nemorideditus Maury	unknown	8	adpressed	convex	mod. high, slightly convex	rounded shoulder, taper to base	raised threads	large, light weight
C. dodona Gardner	3 tapering	7	adpressed	concave	mod. low, concave	elongate, basally constricted	unequal and uneven spaced sinuous threads	heavy shell; rimmed shoulder
C. vitius nom. nov.	3½ tapering	6	distinct, slightly impressed	concave	high, straight-sided	slender, tapering	bands and grooves	small, slender, fusiform; bands and grooves cover final whorl

TABLE 3. SHOAL RIVER FORMATION

SPECIES	NUCLEAR WHORLS	TELEO. WHORLS	SUTURES	ANAL FASCIOLE	SPIRE OUTLINE	BODY OUTLINE	BASAL SCULPTURE	REMARKS
C. drezi n. sp.	unknown	9	distinct, lightly adpressed	concave	mod. high, flat-sided	grad. taper, base constricted	flat spiral bands, striated grooves	early post-nuc. whorls axially costate; smooth flat rim on shoulders
C. waltonensis Aldrich	3½	8	impressed	concave	mod. high, straight-sided	stubby	bands and grooves	numerous or few pustules on final whorl
C. infulatus nom. nov.	2	8	distinct	flat-concave	mod. high, concave	inflated in front of shoulder, base constricted	bands and grooves	heavy shell; bands and grooves cover final whorl
C. submoniliferus Gardner	unknown	10	deeply impressed	concave	low, straight-concave	grad. taper.	beaded spiral threads	spiral lineation on summits of spire whorls

CONUS CHIPOLANUS Dall
Pl. 1, figs. 1, 2

Conus chipolanus DALL, 1896, U. S. Natl. Mus., Proc., v. 18, p. 42; 1903, Wagner Free Inst. Sci., Trans., v. 3, pt. 6, pl. 60, fig. 23.
Conus chipolanus Dall. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 360, pl. 43, fig. 6.
Conus aff. *C. chipolanus* Dall. WOODRING, 1970, U. S. Geol. Surv. Prof. Paper 306-D, p. 354.

Diagnosis: "Shell double-conic, with a rather elevated spire of 9 normal and about 3 lucid nuclear whorls; profile of the spire somewhat concave, turreted shoulder of the whorls sharply keeled, concave between the keel and the suture, without spiral grooving but showing faint microscopic spiral scratches, the prominent sculpture of this area being the delicately arched lines of the anal fasciole, which are sometimes very conspicuous; the keel is wholly without nodules; sides in front of the keel straight, slightly concave toward the canal, smooth, except for incremental lines, polished anteriorly, with about 9 sharp, channeled spiral grooves, besides some striations on the canal; the grooves are separated by wider interspaces and crossed by numerous elevated lines of growth, which only appear in the channels; each channel in the fully adult shell has a spiral row of faint, round tubercles close to its anterior margin; in the young the grooves sometimes cover the whole shell before the keel, and the nodules are often absent; in the adult the grooves cover somewhat less than half the whorl, while on the smooth part traces of 5 narrow, revolving color bands are sometimes visible, with wider interspaces; anal notch moderately deep; outer lip thin, only moderately arched; aperture narrow, with nearly parallel sides; the pillar straight, thin, slightly twisted." (Dall, 1896)

Dimensions of holotype: height 32.0 mm, diameter 15.0 mm.

Holotype: USNM 113985.

Type locality: USGS 2213, one mile below Bailey's Ferry, Chipola River, Calhoun County, Florida (=TU 457).

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 1, USNM 220093; height 29.1 mm (decollate), diameter 12.8 mm; locality TU 546. Fig. 2, USNM 220094; height 33.3 mm, diameter 14.1 mm; locality TU 458. Other occurrences: TU locality nos. 70,196,456, 457, 458, 459, 547, 553, 554, 655, 708, 709, 710, 711, 786, 787, 817a, 820b, 821, 823, 825, 826, 827, 828, 830, 950, 951, 998, 999, 1020, 1021, 1047, 1048, 1050, 1051, 1052, 1097, 1098.

Discussion: Of the nearly 1400 specimens of *C. chipolanus* in the writer's collection 1250 were taken from Ten Mile Creek localities. To study the variability of the species the over 500 specimens taken from a

single locality—TU 546—were used as a representative unit. Dall stated in his diagnosis of the species: ". . . in the young the grooves sometimes cover the whole shell before the keel, and the nodules are often absent; in the adult the grooves cover somewhat less than half the whorl." In the material studied, fewer than 20% (91 specimens) had sculpture (bands and grooves) covering the entire final whorl, and of these 50% were adult, as evidenced by the 9 teleoconch whorls. These adult shells are more slender and the spires less attenuated than those adult specimens with fewer bands and grooves on the final whorl. No pustules were noted on any of these 91 specimens. However, pustules were observed on 30% of the entire lot from TU 546.

The early whorls of *C. chipolanus* can be divided into three stages: nuclear stage of three and one-quarter whorls, curved-rib stage of one-quarter turn, and keeled stage. Even though the outline of the shell and ornamentation of the final whorl show a great amount of variability the details of the early whorls are constant.

Dall (1896) suggested that *C. chipolanus* is related to *C. marylandicus* Green "of the newer Miocene" and to *C. floridanus* Gabb of the Recent Caribbean, but the Chipola species bears only a slight resemblance to either species. *C. marylandicus* is a stout cone with channeled whorls and has a much lower and broader spire with straight to convex outline. The final turn is not constricted basally. The early whorls of *C. floridanus* are axially costate in front of the carinated shoulders and the ornament of the last whorl consists of a few unevenly spaced impressed lines, with no incremental striation. The early whorls of *C. jaspideus* Gmelin, another Recent Caribbean species, are more in agreement with those of *C. chipolanus*, although they lack the curved-rib stage. This Recent species is smaller and has a broader biconic outline, nevertheless, in the opinion of the writer, it could more logically be given consideration as a descendent of the lower Miocene species than could either of the others.

CONUS DEMIURGUS Dall
Pl. 1, figs. 3-5

Conus demiurgus DALL, 1896, U. S. Natl. Mus., Proc., v. 18, p. 43; 1903, Wagner Free Inst. Sci., Trans., v. 3, pt. 6, pl. 60, fig. 22.

Conus demiurgus Dall. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 358, pl. 43, fig. 1.

Diagnosis: "Shell large, elongate, with a large, somewhat bulbous nucleus, and about 10 subsequent whorls; spire low, in the young nearly flat, with a distinct but not channeled suture; shoulder of the whorl angular, the space between the sutures flattish or feebly excavated, sculptured with obvious lines of growth, crossed by few faint, obsolete spiral traces; sides of the whorl smooth, except for obsolete spiral lines, rather wide and irregularly spaced; in the anterior third they are stronger, but even there not very marked; some specimens seem to indicate a faded color pattern of continuous, narrow spiral lines, rather evenly and uniformly spaced; aperture narrow, of equal width or nearly so; the anal notch moderately deep, the pillar straight, with a narrow callous part not showing any ridge or plait." (Dall, 1896)

Dimensions of holotype: height 65.0 mm, diameter 35.0 mm.

Holotype: USNM 113920.

Type locality: USGS 2213, one mile below Bailey's Ferry, Chipola River, Calhoun County, Florida (=TU 457).

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 3, USNM 220095; height 52.5 mm, diameter 27.9 mm; locality TU 825. Fig. 4, USNM 22096; height 7.0 mm, diameter 3.2 mm; locality TU 825. Fig. 5, USNM 220097; height 41.4 mm, diameter 22.5 mm; locality TU 548. Other occurrences: TU locality nos. 457, 458, 459, 546, 547, 554, 555, 817a, 818, 819, 820b, 821, 822, 824, 826, 827, 830, 950, 951, 998, 999, 1050, 1052.

Discussion: The most outstanding characteristic of *C. demiurgus* is its bulbous nucleus tipped with an erect, pointed calcarella, more reminiscent of the family Volutidae than Conidae. This feature is observed on only the very young (see pl. 1, fig. 4) and is abraded long before reaching adulthood with only a round knob-like nucleus of about two whorls remaining.

C. demiurgus is well represented throughout the Chipola Formation, but it is not considered to be abundant at any one locality. About 25% of the 450 specimens examined were taken from Ten Mile Creek localities, the remainder evenly divided

between the Chipola River and Farley Creek. Regardless of locality this species shows only a minor degree of variability. Many of those taken from certain river localities (TU 459 in particular) retain traces of their original color pattern. This species fluoresces well and shows a brilliant pattern with the aid of ultraviolet light (pl. 1, fig. 5).

CONUS ISOMITRATUS Dall
Pl. 1, figs. 6, 7

Conus isomitratus DALL, 1896, U. S. Natl. Mus., Proc., v. 18, p. 43; 1903, Wagner Free Inst. Sci., Trans., v. 3, pt. 6, pl. 60, fig. 26.

Conus isomitratus Dall. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 358, pl. 43, fig. 2.

Diagnosis: "Shell small, solid, short, stout, with a rather low spire of 8 or 9 whorls beside the nucleus; a single elevated thread runs at the shoulder, on which the suture is laid; between the sutures, which are deep and distinct, the whorl is convex, turgid, with only incremental lines; in front of the shoulder the sides are slightly swollen, the posterior half obsoletely spirally striate or smooth, anteriorly with distinct spiral threads and equal interspaces crossed by conspicuous lines of growth; the siphonal fasciole distinct, swollen, showing as a rounded ridge; outer lip straight, thin, sharp; anal notch shallow, aperture narrow, siphonal notch deep; pillar with the edge thickened and twisted, forming in well-developed specimens with the siphonal fasciole two obscure plaits; body with little or no callus." (Dall, 1896)

Dimensions of holotype: height 28.0 mm, diameter 17.5 mm.

Holotype: USNM 113980.

Type locality: USGS 2212, one mile west of Bailey's Ferry, Ten Mile Creek, Calhoun County, Florida (=TU 546).

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 6, USNM 220098; height 31.1 mm, diameter 18.6 mm; locality TU 546. Fig. 7, USNM 220099; height 30.2 mm, diameter 20.4 mm; locality TU 546. Other occurrences: TU locality nos. 70, 196, 457, 458, 459, 547, 548, 549, 554, 555, 655, 710, 786, 787, 806, 810, 817a, 818, 819, 820b, 821, 822, 823, 824, 825, 826, 827, 828, 830, 831, 949, 950, 951, 998, 999, 1020, 1021, 1047, 1048, 1049, 1050, 1051, 1052, 1097, 1098.

Discussion: *Conus isomitratus* has the dual distinction of being not only the most abundant but also the most variable of any *Conus* species in the Chipola Formation. The writer has in her collection over 10,000 specimens of Chipola *Conus* and nearly 50% of these can be categorized as some form of *C. isomitratus*. The criteria for distinguishing this species are the slender two-whorled nucleus, unornamented early teleoconch whorls, impressed sutures, and convex anal fasciole. The spire whorls of the holotype are extremely turgid and the shoulder appears rounded or "dropped" because of the cord that outlines it. The shell is stocky with little basal constriction. The spiral cords on the anterior half of the final volution are evenly spaced. Only 21.5% of the specimens of this species in the writer's collection can be classified as "typical" *C. isomitratus*. The remaining individuals display a wide degree of variation in height of spire, convexity and sometimes lineation of spire whorls, outline and ornamentation of final whorl. It is probable that these variants are the result of hybridization between *C. isomitratus* and *C. sulculus* as they show features of both species. This subject is discussed further under *C. sulculus*.

Dall (1896) stated: "The young of this species have 9 or 10 deep grooves, with narrower interspaces, covering a little more than the anterior half of the shell. These grooves during growth become gradually modified to the adult sculpture." A paratype, USNM 113984, is an example of Dall's "young of the species." Examination of this paratype revealed that the identification was in error. In many instances the ornamentation of the final whorl of a cone will alter as the shell becomes adult, intercalary threads may be added or the existing cords become stronger and more crowded. However, bands and grooves do not change to cords nor do cords change to bands and grooves. The sutures of Dall's paratype are closely adpressed and the spire whorls are carinate and concave. His specimen bears no relationship to *C. isomitratus* but is actually an adult specimen of a somewhat common cone, *C. aneuretos* n. sp. described and figured in the present paper.

CONUS SULCULUS Dall
Pl. 1, figs. 8-10

Conus isomitratus var. *sulculus* DALL, 1896, U. S. Natl. Mus., Proc., v. 18, p. 43; 1903, Wagner Free Inst. Sci., Trans., v. 3, pt. 6, pl. 60, fig. 27.

Conus sulculus Dall. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 359, pl. 43, fig. 3.
Not *Conus sulculus* Dall. PERRILLIAT MONTOYA, 1963, Paleontologia Mexicana, no. 14, p. 28, pl. 6, figs. 11, 12.
Conus cf. *C. sulculus* Dall. WOODRING, 1970, U. S. Geol. Surv. Prof. Paper 306-D, p. 349.

Diagnosis: "Shell resembling the type [of *C. isomitratus*] except that the sutural border or shoulder of the shell is flattened or excavated with a few or numerous spiral grooves upon its surface. It is also larger." (Dall, 1896)

Adult shell large, flat spired, consisting of ten teleoconch whorls plus two and one-half nuclear whorls. Sutures adpressed. Spire whorls flat to concave, sculptured with three to five spiral threads. Spiral lineation appearing on fourth or fifth whorl beginning with one thread in front of suture, rapidly increasing in number. Growth lines moderately arcuate. Outer lip nearly straight; anal notch moderately deep; anal fasciole concave. Shoulder subacute; final whorl with a slight bulge at posterior third, tapering rapidly to base. Anterior third of shell with numerous, close-set sinuous threads, alternating in size. Heavier threads may be pustulated in juvenile specimens.

Dimensions of holotype: height 39.0 mm, diameter 22.0 mm.

Holotype: USNM 113924.

Type locality: USGS 2212, one mile west of Bailey's Ferry, Ten Mile Creek, Calhoun County, Florida (=TU 546).

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 8, USNM 220100; height 47.5 mm, diameter 28.0 mm; locality TU 458. Fig. 9, USNM 220101; height 26.6 mm, diameter 14.0 mm; locality TU 951. Fig. 10, USNM 220102; height 42.9 mm, diameter 24.0 mm; locality TU 998. Other occurrences; TU locality nos. 70, 196, 456, 457, 459, 546, 547, 548, 549, 550, 553, 554, 555, 655, 708, 709, 711, 786, 787, 810, 817a, 818, 820b, 821, 824, 825, 827, 828, 830, 831, 949, 950, 999, 1021, 1047, 1050, 1051, 1052, 1097, 1098.

Discussion: C. sulculus was considered by Dall to be a subspecies of *C. isomitratus.* He stated: "The transition from a concave to a turgid sutural border, from smooth to spirally grooved, is quite gradual, though the extremes have a very different aspect, and would, by some writers, be put in different sections of the genus." Gardner (1937) chose to give it full specific rating, commenting, "*Conus sulculus* Dall is most certainly near of kin to *C. isomitratus* Dall, but it is so readily separable by reason of its larger size, more attenuated anterior portion, and sulcated shoulder and is connected with *C. isomitratus* by so few intermediate forms that it seems worth while to give it specific rank." Examination by the writer of nearly 5,000 specimens showed that *C. sulculus* is distinct from *C. isomitratus.* The identifying features, such as the nucleus, early whorls, sutures and anal fasciole are considerably different in the two species. However, the apparent cross-breeding of *C. isomitratus* and *C. sulculus* resulted in numerous and varied intermediate forms. These possess morphological characteristics of both species to a greater or lesser degree and the only criterion that can be used for separation is the suture, adpressed in *C. sulculus,* impressed in *C. isomitratus.* Any attempt to further divide the in-between forms would result in cluttering the literature with a multitude of names.

The basic color pattern of interrupted close-set spiral lines, shown by aid of ultraviolet light, is evident on both *C. sulculus* and *C. isomitratus* (see pl. 1, fig. 10 and pl. 1, fig. 7). *C. sulculus* s. s. has three distinct bands of large blotches and *C. isomitratus* s. s. has an evenly distributed pattern of small markings. The hybrid forms, if more nearly like *C. isomitratus,* may have one medial band, while others that are more similar to *C. sulculus* may have two bands. The color pattern alone can not be used as a means of identification. Many of the larger and better preserved *C. sulculus* show no pattern whatsoever, others show spiral lines only. This does not necessarily signify that in life the color was lost as the shell matured, as for example is true with *C. fergusoni* Sowerby, a Recent species of the Eastern Pacific. A more plausible explanation may be that the larger sized *C. sulculus* possess a thicker than normal final coating of enamel that partially retards the penetration of ultraviolet light. Fossil *Cypraea, Oliva* and *Marginella* have distinctive patterns but they cannot be revealed with ultraviolet light until the outer layer of enamel is removed.

Perrilliat Montoya (1963) reported *C. sulculus* from the Agueguexquite Formation of Mexico. Her figured specimen portrays a cone with beaded early spire whorls, a feature not found in *C. sulculus.*

CONUS ANEURETOS
S. E. Hoerle, n. sp.
Pl. 2, figs. 1, 2

Diagnosis: Shell broad for the height; medium high spire; last whorl rapidly tapering with slight basal constriction. Slender protoconch of three whorls, eight teleoconch whorls in adult specimens. Spire outline slightly concave; shoulders sharply keeled; sutures closely adpressed. Summits of early spire whorls flat, later ones concave; close-set moderately arcuate growth lines. Anterior half of last whorl ornamented with eight broad, flat, spiral bands, decreasing in width anteriorly, bands separated by incrementally striated grooves. Outer lip moderately arched, anterior portion crenated in harmony with basal sculpture. Siphonal fasciole slightly bulging.

Dimensions of holotype: height 17.5 mm, diameter 10.1 mm.

Holotype: USNM 220103.

Type locality: TU 825, Farley Creek at abandoned mill about ¼ mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 1, USNM 220103 (holotype). Fig. 2, USNM 220104; height 17.6 mm, diameter 10.7 mm; locality TU 546. Other occurrences: TU locality nos. 458, 548, 554, 818, 819, 820b, 821, 822, 823, 824, 826, 827, 828, 830, 951, 998, 999.

Discussion: This new species is distinguished by its small size, slender, three-whorled nucleus, closely adpressed sutures, unornamented, concave spire whorls and keeled shoulder. The basal sculpture shows no change at any period of growth, although a few pustules may be scattered along the broad bands that encircle the final whorl. However, this is the exception not the rule.

C. aneuretos is remarkably constant in outline from the juvenile to the adult stage. Many species show a change in the height of the spire, usually lowering with growth, and

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PLATE I

Figures Page

1,2. *Conus chipolanus* Dall (X2) 6
1. USNM 220093; height 29.1 mm (decollate), diameter 12.8 mm.
Locality: TU 546, Ten Mile Creek.
2. USNM 220094; height 33.3 mm, diameter 14.1 mm.
Locality: TU 458, Chipola River.
3-5. *Conus demiurgus* Dall 7
3. (X1½) USNM 220095; height 52.5 mm, diameter 27.9 mm.
Locality: TU 825, Farley Creek.
4. (X10) USNM 220096; height 7.0 mm, diameter 3.2 mm.
Locality: TU 825, Farley Creek.
5. (X1½) USNM 220097; height 41.4 mm, diameter 22.5 mm.
Locality: TU 548, Chipola River.
6,7. *Conus isomitratus* Dall (X2) 8
6. USNM 220098; height 31.1 mm, diameter 18.6 mm.
Locality: TU 546, Ten Mile Creek.
7. USNM 220099; height 30.2 mm, diameter 20.4 mm.
Locality: TU 546, Ten Mile Creek.
8-10. *Conus sulculus* Dall 8
8. (X1½) USNM 220100; height 47.5 mm, diameter 28.0 mm.
Locality: TU 458, Chipola River.
9. Young specimen showing basal pustules.
(X2) USNM 220101; height 26.6 mm, diameter 14.0 mm.
Locality: TU 951, Ten Mile Creek.
10. (X1½) USNM 220102; height 42.9 mm, diameter 24.0 mm.
Locality: TU 998, Ten Mile Creek.

All specimens from the Chipola Formation, lower Miocene. Color patterns as revealed by ultraviolet light.

PLATE 1

oftentimes a sharp shoulder on a juvenile becomes a rounded shoulder on an adult. These expected outline changes, and lack of them in some species, have added to the confusion of identification in numerous occasions. Possibly this explains Dall's selection of *C. aneuretos* as a paratype and juvenile example of *C. isomitratus.* The Greek word *aneuretos,* meaning "undiscovered," is selected for this species as the taxa so aptly describes the fate of this *Conus* since 1896. (See final paragraph of discussion under *C. isomitratus.*)

Of the nearly 500 specimens in the writer's collection 70% were collected from Farley Creek, 28% from localities on Ten Mile Creek, and the remaining 2% from the Chipola River.

The color pattern of *C. aneuretos* (pl. 2, fig. 2) is unique to the Chipola cones. The other species of this formation have a basic similarity, close-set, interrupted spiral lines overlain with a definite design. This new species shows only solid spiral stripes, with no overlay of design.

CONUS GARDNERAE
S. E. Hoerle, *nom. nov.*
Pl. 2, fig. 3

Conus corrugatus GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 360, pl. 43, fig. 9. *Non Conus corrugatus* Sowerby, 1870, Proc. Zool. Soc., London, p. 257, pl. 22, fig. 7.

Diagnosis: "Shell rather small, biconic, the sharply angulated periphery of the body forming the base of each cone. Spire rather high, approximately one-third the altitude of the entire shell. Whorls ten or more, including the 3 or 4 turns of the protoconch. Nuclear turns small, polished, laterally compressed, and very gradually increasing in size; line of differentiation between conch and protoconch marked by the abrupt initiation of the angulated shoulder and the incremental sculpture. Whorls of conch increasing in size with a moderate degree of rapidity, the sides of the spire serrated by the projecting peripheries of the successive volution. Shoulder behind the periphery conspicuously flattened as a rule, a broad spiral fillet being thus formed, which is persistent in some individuals almost to the nucleus. Sculpture of the spire restricted to arcuate incremental striations that mark the former presence of the posterior siphonal notch and restricted, in those individuals that are conspicuously flattened upon the front part of the shoulder, to the area between the fillet and posterior suture. Sutures distinct, even a little impressed. Body whorl sculptured with 12 or more low, broad spiral bands and in front of these upon the anterior canal 4 to 6 crowded lirae; interspirals linear in most individuals and finely striated by the incrementals. Aperture more than half the altitude of the entire shell, rather narrow, with subparallel margins. Outer lip thin, sharp, deeply indented upon the shoulder for the protrusion of the posterior siphon. Inner lip oblique, parietal wall smooth. Anterior canal slightly flaring, obliquely truncate." (Gardner, 1937)

Dimensions of holotype: height 15.5 mm, diameter 7.9 mm.

Holotype: USNM 349864.

Type locality: USGS 2646, Oak Grove, west bank of Yellow River, Okaloosa County, Florida (=TU 91).

Occurrence: Chipola Formation and Oak Grove Sand, Florida; late lower Miocene.

Figured specimen: USNM 220105; height 13.8 mm, diameter 6.8 mm; locality TU 546. Other occurrences: TU locality nos. 457, 458, 459, 547, 554, 555, 655, 817a, 820b, 821, 825, 830, 831, 951, 998, 999.

Discussion: The specific name *C. corrugatus* of Gardner is preoccupied by that of the Recent species, *C. corrugatus* Sowerby, 1870 (Proc. Zool. Soc., p. 257, pl. 22, fig. 7. Habitat unknown. Type in British Museum.). The new name *C. gardnerae* is here proposed for this species.

Gardner (1937) noted that the species "has a meager distribution in the Chipola, but in the Oak Grove sand it is abundant and widely distributed." Of the 110 specimens in the writer's collection, 85% were taken from Ten Mile Creek; however, the species is also represented at Chipola River and Farley Creek localities.

C. gardnerae can be readily distinguished from *C. chipolanus* by its stouter outline, smaller size, and lack of the curved-rib stage that is noted on *C. chipolanus.* Pustules have been observed on a few specimens. They are positioned medially along the broad spiral bands whereas those on *C. chipolanus* are smaller and placed on the adapical edge of the bands.

Although the size and outline of *C. gardnerae* are nearly in agreement with those of the Recent Caribbean *C. jaspideus* Gmelin the nuclei and details of the spire whorls are totally different. The nucleus of the Recent species has fewer whorls and the summits of the spire whorls do not have the flattened area seen on *C. gardnerae.*

CONUS AMBONOS
S. E. Hoerle, n. sp.
Pl. 2, fig. 4

Diagnosis: Shell thin; moderately low spire; attenuated basally. Adult specimens consisting of eight teleoconch whorls plus three slender nuclear whorls; sides of first three post-nuclear whorls axially costate. Summits of spire whorls concave, marked by strong, moderately arcuate growth lines; shoulders elevated, forming a ridge; sutures adpressed. Anal fasciole concave; outer lip slightly arched. Aperture uniformly narrow. Anterior third of last whorl ornamented with twelve to fifteen unequal-sized and unevenly-spaced flattened cords.

Dimensions of holotype: height 34.6 mm, diameter 18.2 mm.

Holotype: USNM 220106.

Type locality: TU 546, Ten Mile Creek, about 1½ miles west of Chipola River (NW ¼ Sec. 12, T1N, R10W), Calhoun County, Florida (?=USGS 2212, "one mile west of Bailey's Ferry").

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimen: USNM 220106 (holotype). Other occurrences: TU locality nos. 547, 554, 830, 950, 951, 998.

Discussion: C. ambonos is an uncommon species in the Chipola Formation and has a limited geographic range. With the exception of three juveniles taken from river localities, all of the specimens were collected along Ten Mile Creek. The shell is delicate and extremely fragile, consequently, the final whorl is always damaged.

The elevated, rimmed shoulder and concave summits of the spire whorls are similar to those of a more massive shell, *C. dodona* Gardner, from the Oak Grove Sand (see pl. 4, fig. 8). However, the early post-nuclear whorls of *C. dodona* show no axial costae, a characteristic feature of *C. ambonos.* Also, the Oak Grove species has a more excavated anal fasciole and is not as attenuated and constricted basally.

This species derives its name from the Greed word *ambonos* meaning "rim" or "ridge".

CONUS TRAJECTIONIS Maury
Pl. 2, figs. 5, 6

Conus trajectionis MAURY, 1910, Bulls. Amer. Paleontology, v. 4, no. 21, p. 5, pl. 1, fig. 6.
Conus trajectionis Maury. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 359.
Conus trajectionis Maury. JUNG, 1965, Bulls. Amer. Paleontology, v. 49, no. 233, p. 576, pl. 78, figs. 3, 4.

Diagnosis: "Shell of medium size, elongately pyriform, with an elevated and very acute spire not convex in profile; whorls 11, of which the first 2 nuclear are smooth, the 5 following show a coronation under the lens, while the remainder have only a spiral ornamentation. Spiral sculpture of 3 or 4 strong threads on each volution of the spire. The spirals are absent on the last whorl below the shoulder but are strongly developed near the base of the shell. Lines of growth inconspicuous." (Maury, 1910)

Shell slender, pyriform, attenuated anteriorly. Three and one-half tapering nuclear whorls plus ten teleoconch whorls in adult specimens, first four and one-half coarsely noded, nodes decreasing in size and number with each succeeding turn. Sutures distinct, lightly adpressed. Summits of whorls flat, with spiral lineation; growth lines inconspicuous, slightly opisthocyrt. Anal fasciole flat; anal notch shallow; lip nearly straight. Posterior two-thrids of last whorl with obsolete spiral threads, becoming more pronounced and roughened by growth lines on anterior third.

Dimensions of holotype: height 52.0 mm, diameter 27.7 mm.

Holotype: PRI 3429.

Type locality: "Bailey's Ferry, Florida." TU locality 459, east bank of Chipola River, above Farley Creek (SW ¼ Sec. 20, T1N, R9W), Calhoun County, Florida (here designated).

Occurrence: Chipola Formation, Florida; late lower Miocene. Unnamed formation, Paraguaná Peninsula, Venezuela; late lower Miocene.

Figured specimens: Fig. 5, USNM 220107; height 41.0 mm, diameter 22.0 mm; locality TU 951. Fig. 6, USNM 220108; height 10.6mm, diameter 5.3 mm; locality TU 951. Other occurrences: TU locality nos. 70, 459, 546, 548, 830.

Discussion: Maury had only one specimen from which she described and figured her species *C. trajectionis.* Gardner (1937) stated: "Nothing specifically identical with Miss Maury's *trajectionis* is included in our collections" and suggested that it had much in common with *C. sulculus.* The writer disagrees with this contention. A detailed description, based on the study of 25 specimens, is given above to more clearly define the points of dissimilarity between *C. trajectionis* and *C. sulculus.*

The mere fact of the post-embryonic whorls being noded is sufficient criterion to differentiate this species from *C. sulculus.* In the juvenile stage *C. trajectionis* could possibly be confused with *C. cracens* n. sp., reported in the present paper, but upon examination of the summits of the spire whorls (*C. cracens,* summits concave with strong arcuate growth lines; *C. trajectionis,*

summits flat with inconspicuous growth lines), the two species may be readily distinguished.

Jung (1965) reported the finding of two specimens of *C. trajectionis* from the Paraguaná Peninsula, Venezuela. These are deposited at the Natural History Museum, Basel, Switzerland. The writer has not seen these specimens but Jung's description and figures coincide with the species. It is not unknown for the same species to occur in both the Chipola Formation and the Paraguaná Peninsula of Venezuela. Other examples are *Potamides suprasulcatus* (Gabb), *Aturia curvilineata* Miller and Thompson and *Murexiella (Subpterynotus) textilis* (Gabb). In a recent paper on the microfauna of the Cantaure Formation, Diaz de Gamero (1974) indicates the age to be Burdigalian (Zones N7 and N8 of Bolli), in which case the two formations are exact equivalents in age.

Maury designated "Bailey's Ferry, Florida" as the type locality for *C. trajectionis* but there is no Chipola Formation at that site. Undoubtedly her specimen was obtained further downstream where there are numerous exposures of the marl. Only two of the 25 specimens studied for this paper were from Chipola River localities (TU 459, Drez coll., and TU 548, Tulane University coll.). TU 459 is here designated as the type locality for *Conus trajectionis.* The remaining 23 specimens came from localities along Ten Mile Creek, twelve of these were from TU 951.

No color pattern appears under ultraviolet light on any of the specimens. Either they were a solid color, devoid of pattern, or conditions were such that they were unable to retain a pattern.

CONUS CRACENS
S. E. Hoerle, n. sp.
Pl. 3, figs. 1-3

Diagnosis: Shell large, thin, tapering, low spire and angulated shoulder. Adult specimens consisting of ten teleoconch whorls, plus three slender, nuclear whorls. Tubercles and spiral threading beginning simultaneously on first post-nuclear whorl, tubercles continuing for about seven whorls, spiral lineation constant and moderately strong. Close-set arcuate growth lines cutting, at times roughening, the spiral lineation. Sutures distinct, lightly adpressed. Anal fasciole concave; anal notch deep; outer lip arched forward. Widely spaced incised lines encircling medial portion of last whorl, ornament gradually changing to crowded, wavy, unevenly-spaced, flattened cords around base. Aperture narrow with a slight flare anteriorly; no siphonal notch.

Dimensions of holotype: height 37.8 mm, diameter 20.0 mm.

PLATE 2

Figures Page

1,2. *Conus aneuretos* S. E. Hoerle, n. sp. 10
1. (X4) USNM 220103 (holotype); height 17.5 mm, diameter 10.1 mm.
Loclaity: TU 825, Farley Creek.
2. (X3) USNM 220104; height 17.6 mm, diameter 10.7 mm.
Locality: TU 546, Ten Mile Creek.
3. *Conus gardnerae* S. E. Hoerle, *nom. nov.* (X4) 12
USNM 220105; height 13.8 mm, diameter 6.8 mm.
Locality: TU 546, Ten Mile Creek.
4. *Conus ambonos* S. E. Hoerle, n. sp. (X2) 13
USNM 220106 (holotype); height 34.6 mm, diameter 18.2 mm.
Locality: TU 546, Ten Mile Creek.
5,6. *Conus trajectionis* Maury 13
5. (X2) USNM 220107; height 41.0 mm, diameter 22.0 mm.
Locality: TU 951, Ten Mile Creek.
6. (X10) USNM 220108; height 10.6 mm, diameter 5.3 mm.
Locality: TU 951, Ten Mile Creek.

All specimens from the Chipola Formation, lower Miocene. Color patterns as revealed by ultraviolet light.

PLATE 2

Holotype: USNM 220109.

Type locality: TU 655, Ten Mile Creek, about 0.1 mile downstream from bridge of Florida Highway 73 (NW ¼ Sec. 29, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 1, USNM 220109 (holotype). Fig. 3, USNM 220111; height 19.4 mm, diameter 10.5 mm; locality TU 546. Fig. 2, USNM 220110; height 52.1 mm, diameter 28.3 mm; locality TU 830. Other occurrences: TU locality nos. 70, 196, 456, 457, 459, 554, 787, 817a, 820b, 825, 826, 951, 999, 1050, 1098.

Discussion: C. cracens, although not common at any one locality, is well represented throughout the Chipola Formation and attains a greater size (60 to 70 mm) than other members of the group. One specimen in the Tulane University collection (TU 458) measures 87.8 mm in height and 52.5 mm in diameter. In this gerontic stage the rim disappears and the shoulder becomes rounded, the base is less constricted and the entire appearance is one of massiveness.

C. cracens appears to be a descendant of the widespread (Alabama, Mississippi, Texas) middle Eocene to Oligocene species, *C. sauridens* Conrad. The development of the early post-nuclear whorls is identical in the the two species, as is also true of the anal fasciole, the forward arch of the outer lip and the rimmed shoulder. Although the two species have a number of characteristics in common, there are consistent differences, justifying the new specific name for the Chipola form. The nodes on the spire whorls persist for a greater number of turns on *C. cracens,* also it is larger, more slender, with stronger and more opisthocyrt growth lines and more pronounced basal ornament.

C. stenostoma Sowerby reported from the (?) middle Miocene of Santo Domingo and Costa Rica and the (?) upper Miocene of Bowden, Jamaica and Springvale, Trinidad, possibly is derived from the Chipola species *C. cracens.* The affinity is shown by the three-whorled nucleus, the tuberculation of the first three to five post-nuclear whorls, the spiral lineation, the concave fasciole, the rimmed shoulders and arched outer lip. However, the sutures of *C. stenostoma* are more closely adpressed and the shell is consistently more attenuated anteriorly with less crowded basal ornament. Under ultraviolet light this species displays a different collor pattern (broken spiral lines plus two solid spiral bands) in contrast to only broken spiral lines observed on *C. cracens.*

Cracens, Latin for "slender," "graceful," was selected as an appropriate description of this species.

CONUS TAPETUS
S. E. Hoerle, n. sp.
Pl. 3, figs. 4, 5

Diagnosis: Shell nearly straight-sided, low spired, early whorls elevated. Adult specimens with nine teleoconch whorls plus one and three-quarters smooth, broadly rounded nuclear whorls. First three or four post-protoconch whorls with beaded shoulders, remainder smooth. Sutures lightly adpressed, bounded in front by a cord. Summits of spire whorls flat, ornamented with spiral threads; growth lines faint, close-set, arcuate. Anal fasciole flat; shoulder subacute; outer lip nearly straight in front of deep anal notch. Columella straight with a slight thickening at base; scarcely discernible siphonal fasciole. Spiral sculpture on last whorl confined to anterior third of the shell, consisting of eight to twelve unequal and inequispaced flattened cords, heavier on their adapical edge.

Dimensions of holotype: height 31.6 mm, diameter 17.4 mm.

Holotype: USNM 220112.

Type locality: TU 547, west bank of Chipola River, about 2000 feet above Four Mile Creek (SW ¼ Sec. 29, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 4, USNM 220112 (holotype). Fig. 5, USNM 220113; height 8.6 mm, diameter 4.6 mm; locality TU 825. Other occurrences: TU locality nos. 457, 458, 459, 548, 554, 555, 818, 819, 820b, 821, 822, 823, 824, 826, 827, 828, 999, 1020, 1048, 1050.

Discussion: After *C. isomitratus* this new species is the most common of the cones collected by the writer along the Chipola River. The greatest numbers were taken from two coral reef localities, TU 547 (190 specimens) and TU 555 (62 specimens). *C. tapetus* is extremely rare at "one mile below Bailey's Ferry" (TU 457) and does not occur at "one mile west of Bailey's Ferry" (TU 546). As these were the only two localities available to early workers, it is understandable why this distinctive species is totally absent from the older collections.

C. tapetus bears a greater similarity to *C. erugatus* n. sp. than to any other species

from the Chipola Formation. Both have beaded early whorls and a nearly straight-sided outline of the final volution. *C. tapetus* can easily be separated from its congener by the adpressed suture, spiral lineation, and larger size. Adults of *C. tapetus* average 30 to 35 mm whereas those of *C. erugatus* seldom reach 25 mm. This species demonstrates the unreliability of employing basal ornamentation as a diagnostic feature for means of identification. The cords, confined to the anterior third (sometimes to the anterior fifth only) of the shell, may be flattened, rounded, coarse or fine, all within the species.

Those specimens from the river localities TU 547 (type locality) and TU 555 fluoresce exceedingly well (pl. 3, fig. 4b), showing a pattern remarkably like a piece of finely woven tapestry. The Latin word *tapetus,* meaning "tapestry" is descriptive of the species.

CONUS ERUGATUS
S. E. Hoerle, n. sp.
Pl. 3, figs. 6, 7

Diagnosis: Adult shell of eight and one-half teleoconch whorls plus one and one-half well-rounded nuclear whorls. First three or four postnuclear whorls beaded on shoulders, remainder smooth. Spire low except for the much elevated early whorls. Sutures impressed but not channeled. Spire whorls without spiral lineation, or with a single, faint thread midway between suture and shoulder. Slightly arcuate growth lines, not distinct. Shoulder subacute; last whorl nearly flat-sided; anal fasciole flat; anal notch shallow; outer lip nearly straight. Eight to ten coarse spiral cords encircling anterior fifth of shell, cords becoming crowded abapically. Columella straight; anterior canal obliquely truncate.

Dimensions of holotype: height 21.4 mm, diameter 12.0 mm.

Holotype: USNM 220114.

Type locality: TU 825, Farley Creek at abandoned mill about ¼ mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 6, USNM 220114 (holotype). Fig. 7, USNM 220115; height 23.0 mm, diameter 13.2 mm; locality TU 999. Other occurrences: TU locality nos. 457, 458, 459, 547, 554, 818, 819, 820b, 821, 823, 824, 826, 827, 828, 949, 950, 1020, 1049.

Discussion: C. erugatus has a similar outline to *C. tapetus* and both have beaded early whorls. The significant characteristics that differentiate the two species are the impressed sutures and shallow anal notch of *C. erugatus* as opposed to the adpressed sutures and deep anal notch of *C. tapetus.*

The majority of the 274 specimens of *C. erugatus* in the writer's collection were taken from the banks of Farley Creek, the remainder were collected from river localities. This is in exact reversal to the distribution of *C. tapetus.* Neither species has been found to occur on Ten Mile Creek.

Both *C. erugatus* and *C. tapetus* have a basic color pattern of broken spiral lines, but the predominant pattern is consistently different in the two species (see pl. 3, figs. 7b, and 4b).

CONUS AQUOREUS
S. E. Hoerle, n. sp.
Pl. 4, fig. 1

Diagnosis: Shell elongate, straight-sided, low to flat spire. Slender erect nucleus of one and three-quarters turns, nine teleoconch whorls; sutures lightly adpressed; summits of whorls flat to slightly concave, ornamented by weak spiral lineation and crowded, strong, shallowly arcuate growth lines; shoulder acute. Anal fasciole flat to slightly concave; outer lip straight. Irregularly spaced spiral threads confined to abapical fifth of final whorl.

Dimensions of holotype: height 33.5 mm, diameter 19.1 mm.

Holotype: USNM 220116.

Type locality: TU 554, east bank of Chippla River at power line crossing (SW ¼ Sec. 17, T1N, R9W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured Specimen: USNM 220116 (holotype). Other occurrences: TU locality nos. 457, 458, 459, 547, 830, 950, 1050.

Discussion: The distribution of the 250 examined specimens of *C. aquoreus* is confined solely to Chipola River localities, with the exception of two individuals from TU 830. It is a common species at both the type locality, TU 554, and TU 457 ("one mile below Bailey's Ferry"). The reasons for this restricted range are not known; however, it should be noted that other species of the Chipola Formation share the same confines of distribution. One typical example is the muricid *Chicoreus lepidotus* (Vokes).

C. aquoreus can be recognized by its elongate, straight-sided outline, nearly flat spire and erect nucleus of one and three-quarters whorls. The spire whorls are usually ornamented with faint spiral threading although a few individuals show no lineation.

Treatment with sodium hypochlorite solution has failed to produce any fluorescent qualities in specimens of this species. Perhaps the shells were a solid color devoid of pattern in life, as is the Recent Panamic species, *C. patricius* Hinds. The smooth surface of this species is suggestive of the Latin word *aquoreus*.

CONUS VEGRANDIS
S. E. Hoerle, n. sp.
Pl. 4, figs. 2, 3

Diagnosis: Shell small; slender; spire moderately high, flat-sided to slightly concave in outline. Adult specimens consisting of seven teleoconch whorls plus two rounded nuclear whorls. Sutures distinct, lightly adpressed. First three post-nuclear whorls elevated, exposing axially costate ornamentation in front of carinate shoulders. Early spire whorls flat on summits, later whorls barely convex. Growth lines faint, close-set, shallowly opisthocyrt. Microscopic spiral threading present. Shoulder of final whorl outlined by small cord. There is a scarcely perceptible widening of the last whorl at the adapical third. Anal notch shallow; lip nearly straight; aperture narrow posteriorly, widening anteriorly and crenated in harmony with basal sculpture. Abapical third of last whorl ornamented with ten, heavy, rounded cords, separated by narrower, unequal interspaces.

Dimensions of holotype: height 15.1 mm, diameter 8.5 mm.

Holotype: USNM 220117.

Type locality: TU 546, Ten Mile Creek, about 1½ miles west of Chipola River (NW ¼ Sec. 12, T1N, R10W), Calhoun County, Florida (?=USGS 2212, "one mile west of Bailey's Ferry").

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 2, USNM 220117 (holotype). Fig. 3, USNM 220118; height 9.1 mm, diameter 4.8 mm; locality TU 546. Other occurrences: TU locality nos. 196, 457, 458, 459, 554, 655, 710, 830, 950, 951, 998, 1050, 1098.

Discussion: C. vegrandis bears a resemblance to *C. tricoratus* n. sp. in the similar outline, adpressed sutures and axially costate early whorls. Both species have seven teleoconch whorls in the adult stage, however, *C. vegrandis* is consistently slightly larger. The dissimilarities are the two nuclear whorls and convex anal fasciole of *C. vegrandis* as opposed to three nuclear whorls and flat anal fasciole of *C. tricoratus*. The latter

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PLATE 3

Figures Page

1-3. *Conus cracens* S. E. Hoerle, n. sp. 14
1. (X2) USNM 220109 (holotype); height 37.8 mm, diameter 20.0 mm. Locality: TU 655, Ten Mile Creek.
2. (X1¼) USNM 220110; height 52.1 mm, diameter 28.3 mm. Locality: TU 830, Ten Mile Creek.
3. (X8) USNM 220111; height 19.4 mm, diameter 10.5 mm. Locality: TU 546, Ten Mile Creek.
4,5. *Conus tapetus* S. E. Hoerle, n. sp. 16
4. (X2) USNM 220112 (holotype); height 31.6 mm, diameter 17.4 mm. Locality: TU 547, Chipola River.
5. (X10) USNM 220113; height 8.6 mm, diameter 4.6 mm. Locality: TU 825, Farley Creek.
6,7. *Conus erugatus* S. E. Hoerle, n. sp. (X2) 17
6. USNM 220114 (holotype); height 21.4 mm, diameter 12.0 mm. Locality: TU 825, Farley Creek.
7. USNM 220115; height 23.0 mm, diameter 13.2 mm. Locality: TU 999, Farley Creek.

All specimens from Chipola Formation, lower Miocene. Color patterns as revealed by ultraviolet light.

PLATE 3

species has a narrow smooth band in front of the suture. This band is absent on *C. vegrandis.*

Of the over 350 specimens of this small (*vegrandis,* Latin for "little") species collected by the writer 75% were taken from Ten Mile Creek, 25% from Chipola River localities and none were found along Farley Creek.

CONUS PRAECIPUUS
S. E. Hoerle, n. sp.
Pl. 4, fig. 4

Diagnosis: Shell slender, spire high, shoulder rounded; nucleus unknown, nine teleoconch whorls remaining. Spire whorls flat to concave, ornamented with three or four spiral threads; shoulders heavily tuberculate, tubercles absent on final turn; sutures closely adpressed, undulating with the tubercles; anal fasciole narrow and concave; anal notch deep; outer lip arched forward. Sculpture of last whorl consisting of narrow spiral cords, nearly obsolete adapically, stronger abapically.

Dimensions of holotype: height 38.0 mm, diameter 18.7 mm.

Holotype: USNM 220119.

Type locality: TU 546, Ten Mile Creek, about 1½ miles west of Chipola River (NW ¼ Sec. 12, T1N, R10W), Calhoun County, Florida (?=USGS 2212, "one mile west of Bailey's Ferry").

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimen: USNM 220119 (holotype). Other occurrences: TU locality nos. 459, 951.

Discussion: C. praecipuus, an exceedingly rare species, is known from only three specimens, the holotype, a badly eroded paratype measuring 49.0 mm (incomplete) in the writer's collection, and one juvenile paratype, 28.8 mm in height, in the collection of Paul Drez, Chapel Hill, North Carolina. The latter specimen is in somewhat better condition than the other two, but the spiral sculpture on the final whorl is barely discernible. Whether this ornamentation increases with the maturity of the shell or is but a variable feature cannot be stated with any degree of certainty at this time. Additional specimens are needed to clarify this detail. Morphological characteristics such as the heavy tubercles, narrow, concave fasciole, deeply arcuate growth lines and prosocyrt labrum, are common to the three specimens examined.

C. praecipuus possibly is ancestral to *C. consobrinus* Sowerby, commonly found in (?) Miocene localities of Santo Domingo, Panamá, Mexico, and Jamaica, as there is a marked resemblance in the two species. *C. consobrinus* is not known from southeastern United States. The high spire with heavy tubercles on the whorls, low rounded shoulder, attenuated and strongly sculptured final whorl all tend to make *C. consobrinus* a distinctive species. *C. praecipuus* is not as elongate, nor is the final volution as strongly ornamented; however, the similarity between the two species is apparent.

No species similar to *C. consobrinus* has been reported from beds earlier than (?) upper Miocene. Because of the age differentiation and minor diagnostic features, the writer deems it more judicious at this time to give full taxonomic recognition to the Chipola form.

CONUS TRICORATUS
S. E. Hoerle, n. sp.
Pl. 4, fig. 5

Diagnosis: Shell small, anteriorly attenuated, consisting of three slender nuclear whorls and seven teleoconch whorls. Spire high, outline concave; first four post-nuclear whorls elevated, axially costate in front of carinate shoulders; narrow smooth band in front of adpressed sutures; summits of whorls flat, microscopically striate; growth lines feeble and shallow; labrum moderately prosocyrt. Obsolete, widely-spaced spiral cords on adapical two-thirds of final whorl, ten rounded cords, crowded anteriorly, on abapical one-third.

Dimensions of holotype: height 13.3 mm, diameter 6.7 mm.

Holotype: USNM 220120.

Type locality: TU 951, Ten Mile Creek, about 1¼ miles west of Chipola River (SE ¼ Sec. 12, T1N, R10W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimen: USNM 220120 (holotype). Other occurrences: TU locality nos. 457, 458, 546, 655, 817a, 830, 998, 1097.

Discussion: C. tricoratus is the smallest of the Chipola cones, seldom reaching 15.0 mm in height. It could be easily confused with the young of *C. sulculus,* as the outline is similar. However, the resemblance is only coincidental as this new species has a three whorled nucleus and axial ribbing on the early teleoconch whorls. A seven whorled

young *C. sulculus* will be about twice the height of an adult (seven whorls) *C. tricoratus.*

About 100 individuals of this species have been collected and, with the exception of three specimens, all were taken from Ten Mile Creek localities.

CONUS RAPUNCULUS
S. E. Hoerle, n. sp.
Pl. 4, figs. 6, 7

Diagnosis: Shell of medium size, broadly fusiform; eight teleoconch whorls plus three and one-half nuclear whorls in adult specimens. First three post-protoconch whorls axially costate in front of carinate shoulders. Sutures distinct and adpressed; growth lines deeply arcuate. Spiral sculpture restricted to anterior half of last whorl, consisting of broad bands and narrow, incrementally ornamented grooves; bands becoming narrower and crowded on siphonal fasciole. Base constricted; columella with a sharp twist to the left and bent slightly backwards. Anal fasciole flat; anal notch deep; outer lip moderately prosocyrt.

Dimensions of holotype: height 22.5 mm (incomplete), diameter 13.0 mm.

Holotype: USNM 220121.

Type locality: TU 951, Ten Mile Creek, about 1¼ miles west of Chipola River (SE ¼ Sec. 12, T1N, R10W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 6, USNM 220121 (holotype). Fig. 7, USNM 220122; height 19.5mm, diameter 9.8 mm; locality TU 830. Other occurrences: TU locality nos. 196, 457, 459, 546, 655, 710, 998, 1051.

Discussion: C. rapunculus is distinguished by its pronounced tapered outline and the sharp twist on the anterior portion of the columella. Juvenile specimens of this species do not show this latter feature to a great extent. Some large specimens of *C. chipolanus* have the canal slightly recurved but not to the degree that is seen on *C. rapunculus.* While there are minor similarities between these two species, the consistent characteristic that differentiates them is the early post-nuclear whorls. Those of *C. rapunculus* are axially costate and those of *C. chipolanus* are smooth, the only ornament being the curved-rib stage of the first one-quarter turn.

C. rapunculus is another species that occurs almost solely along Ten Mile Creek. Of the total lot of 83 specimens only three were from Chipola River localities and none from Farley Creek. The outer lip is exceedingly fragile and consequently was broken on every individual.

The Latin word *rapunculus,* meaning "turnip," describes the outline of this new species.

CONUS DRAPERI* Maury

Conus draperi MAURY, 1910, Bulls. Amer. Paleontology, v. 4, no. 21, p. 5, pl. 1, fig. 4.
Conus draperi Maury. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 363.
[?] *Conus molis* Brown and Pilsbry. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 363.

Diagnosis: "Shell large, surpassing in size all the other species of the genus yet found in the Chipola beds. General form conic, with 8 whorls exclusive of the eroded nucleus; spire moderately elevated, not convex in profile; last whorl distinctly shouldered; surface of shell eroded in small circular spots, which may be an indication that the original color pattern consisted of small dark spots on a light ground. Transverse sculpture lacking except for faint lines near the base of the shell; lines of growth inconspicuous." (Maury, 1910)

Dimensions of holotype: height 60.0 mm, diameter 38.0 mm.

Holotype: PRI 3427.

Type locality: "Chipola marls, Bailey's Ferry, Calhoun County, Florida." [Oak Grove Sand, exact locality unknown].

Occurrence: Oak Grove Sand, Florida; (?) late lower Miocene.

Discussion: Examination of the benthonic foraminifera found in the matrix of the holotype of *C. draperi* reveals that the specimen is from the Oak Grove Sand fauna, not the "Chipola marls" as was stated by Maury (W. H. Akers, *in litt.*).

Gardner was of the opinion that the "description and figure indicate a shell rather similar to *C. demiurgus* Dall [from the Chipola Formation], but broader relatively and less angular". The writer does not concur with that view. Although the sole representative of Maury's species is in

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*The specific taxon *"draperi"* appears to be a *lapsus* on the part of Maury, as she clearly stated (1910, p. 5), "Named in honor of Mrs. Henry Draper of New York City." The specific name should have the feminine ending, making it *"draperae."*

wretched condition and some of the diagnostic features are abraded it can be stated unequivocally that *C. draperi* bears no resemblance to *C. demiurgus.* A better tentative placement might be in the ancestral line leading to the Recent western Atlantic species *C. spurius* Gmelin.

A worn fragment of a large cone occurring in the Oak Grove Sand was reported by Gardner (1937, p. 363) as *C. molis* Brown and Pilsbry. The specimen is so worn as to be specifically unidentifiable but similarity of size and locality tend to indicate that it is another example of *C. draperi.*

As Gardner (1937, p. 363) noted, the perforations on the type specimen are due to the activities of a boring sponge, rather than indicative of the original color pattern as was suggested by Maury in her diagnosis of the species.

CONUS NEMORIDEDITUS Maury

Conus nemorideditus MAURY, 1910, Bulls. Amer. Paleontology, v. 4, no. 21, p. 5, pl. 1, fig. 5.

Conus nemorideditus Maury. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 363.

Diagnosis: "Shell large, smooth, thin in proportion to its size; whorls eight exclusive of the eroded nucleus; spire moderately elevated, not concave in profile, last whorl of the shell full and rounded near the shoulder and tapering rapidly to a rather slender base. Spiral sculpture consisting only of rather faint raised lines on the lower one-third of the shell; lines of growth inconspicuous." (Maury, 1910)

Dimensions of holotype: height 70.0 mm, diameter 42.0mm.

Holotype: PRI 3428.

Type locality: "Oak Grove, Florida." (?=TU 91),

Occurrence: Oak Grove Sand, Florida; (?) late lower Miocene.

Discussion: The type of *C. nemorideditus* remains unique. Gardner (1937, p. 363) stated: "This species does not appear in later collections" and no similar specimens have been recovered by subsequent collectors. This is not surprising when we consider the fact that *Conus* is not a common genus in the Oak Grove Sand fauna. The holotype of *C. nemorideditus* is poorly preserved and

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PLATE 4

Figures Page

1. *Conus aquoreus* S. E. Hoerle, n. sp. (X2) 17
USNM 220116 (holotype); height 33.5 mm, diameter 19.1 mm.
Locality: TU 554, Chipola River.

2,3. *Conus vegrandis* S. E. Hoerle, n. sp. 18
2. (X4) USNM 220117 (holotype); height 15.1 mm, diameter 8.5 mm.
Locality: TU 546, Ten Mile Creek.
3. (X10) USNM 220118; height 9.1 mm, diameter 4.8 mm.
Locality: TU 546, Ten Mile Creek.

4. *Conus praecipuus* S. E. Hoerle, n. sp. (X2) 20
USNM 220119 (holotype); height 38.0 mm, diameter 19.7 mm.
Locality: TU 546, Ten Mile Creek.

5. *Conus tricoratus* S. E. Hoerle, n. sp. (X4) 20
USNM 220120 (holotype); height 13.3 mm, diameter 6.7 mm.
Locality: TU 951, Ten Mile Creek.

6,7. *Conus rapunculus* S. E. Hoerle, n. sp. (X3) 21
6. USNM 220121 (holotype); height 22.5 mm (incomplete), diameter 13.0 mm.
Locality: TU 951, Ten Mile Creek.
7. USNM 220122; height 19.5 mm, diameter 9.8 mm.
Locality: TU 830, Ten Mile Creek.

8. *Conus dodona* Gardner (X1½) 24
USNM 349858 (holotype); height 33.8 mm, diameter 19.0 mm.
Locality: USGS 2646. Oak Grove Sand, (?) late lower Miocene.

All specimens except as noted from Chipola Formation, lower Miocene. Color patterns as revealed by ultraviolet light.

PLATE 4

nothing would be accomplished by re-figuring the specimen. Maury's figures of both *C. nemorideditus* and *C. draperi* were drawings, not photographs, therefore a certain amount of "artistic license" was involved.

CONUS DODONA Gardner
Pl. 4, fig. 8

Conus dodona GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 359, pl. 43, fig. 4.

Diagnosis: "Shell rather large and heavy. Spire not more than one-fifth of the entire altitude in the adult forms. Whorls approximately 9, including the 2 or 3 nuclear coils, which are small, of nearly the same size, and laterally compressed and form a sharp and prominent little knob in the center of the low spire. Earlier whorls of conch flattened upon the shoulder; later whorls concave, the sutures very closely appressed and the peripheral margin slightly elevated. Incremental sculpture well developed in the concave area between the periphery and the suture. Spiral sculpture restricted to a dozen or more unequal and inequispaced, irregular oblique spirals upon the anterior third of the body. Aperture of average width. Outer lip thin, sharp, deeply emarginate at the shoulder. Inner lip smooth, reinforced at the anterior canal. Anterior canal wide, flaring slightly, obliquely truncated." (Gardner, 1937)

Dimensions of holotype: height 33.8 mm, diameter 19.0 mm.

Holotype: USNM 349858.

Type locality: USGS 2646, Oak Grove, Yellow River, Okaloosa County, Florida.

Occurrence: Oak Grove Sand, Florida; (?) late lower Miocene.

Figured specimen: USNM 349858 (holotype).

Discussion: There is a marked similarity in appearance between *C. dodona* and *C. ambonos* n. sp. from the Chipola Formation, as both species have a concave anal fasciole and rimmed shoulder. However, the Oak Grove species is a much heavier shell with a less constricted base and more excavated anal fasciole. The significant characteristic that differentiates *C. dodona* from *C. amobonos* is the absence of any ornamentation on the early post-nuclear whorls in contrast with the axial costae seen on the Chipola species. Another dissimilarity noted is the color patterns of the two shells as shown under ultraviolet light (see pl. 2, fig. 4b, and pl. 4, fig. 8b).

Gardner (1937, p. 360) reported this cone as "abundant at certain localities" [all of various USGS locality numbers cited by Gardner designated the same locality, "Oak Grove, Yellow River, Okaloosa County, Florida"] but the holotype and 18 paratypes were the only representatives of the species that could be located in the U. S. National Museum. None have been obtained by subsequent collecting. The largest paratype (from USGS 7054) measured 43.8 mm in height, thereby indicating that *C. dodona* does not attain the size of either *C. draperi* or *C. nemorideditus,* two other species from the Oak Grove Sand.

CONUS DREZI
S. E. Hoerle, n. sp.
Pl. 5, fig. 1

Diagnosis: Spire moderately high, flat-sided in outline; shoulder acute; base constricted. Nucleus unknown, nine teleoconch whorls remaining. Sides of first three post-nuclear whorls with coarse axial costae, costae less strong on later whorls, entirely absent by seventh whorl. Summits of early whorls flat, later ones slightly concave. Whorls ornamented with strong, moderately opisthocyrt growth lines and spiral striae, striae confined to adapical half of whorl summits, thus forming a broad, smooth, flat rim on each shoulder. Sutures distinct, lightly adpressed; outer lip with a moderate forward arch; anal fasciole concave. Basal sculpture consisting of twelve flat spiral bands separated by narrower, deep, incrementally ornamented interspaces, the six adapical bands medially grooved, the remainder crowded. Columella straight.

Dimensions of holotype: height 30.0 mm (incomplete), diameter 16.3 mm.

Holotype: USNM 220123.

Type locality: TU 69A, first ravine upstream from Shell Bluff, Shoal River (NW ¼ Sec. 4, T3N, R21W), about 3½ miles north of Mossyhead, Walton County, Florida.

Occurrence: Shoal River Formation, Florida; middle Miocene.

Figured specimen: USNM 220123 (holotype).

Discussion: C. drezi, based on a single specimen, is unlike any other *Conus* species in the Alum Bluff Group. The flat band bordering the shoulders of the spire whorls is the most outstanding diagnostic feature. This characteristic has not been seen by the writer on any other specimens, fossil or Recent. An unnamed species in the middle Pliocene Pinecrest beds of south Florida (see Akers, 1974, p. 119) and the Recent Caribbean *C. stimpsoni* Dall have similar early whorls and concave anal fascioles but both lack the shoulder band.

The color pattern, seen with the aid of ultraviolet light, (pl. 5, fig. 1c) differs from that of any of the species figured in the present paper. It is more suggestive of the pattern sometimes noted on the above mentioned Recent species.

C. drezi is named in honor of its collector, Paul Drez of Chapel Hill, North Carolina, who has a talent for locating unusual specimens.

CONUS VITIUS
S. E. Hoerle, *nom. nov.*
Pl. 5, fig. 2

Conus fusiformis GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 361, pl. 43, fig. 10.
Non Conus fusiformis G. Fischer, 1807, Mus. Demidoff, v. 3, p. 144; *nec Conus fusiformis* Lamarck, 1810, Ann. Mus. Hist. Nat. (Paris), v. 15, p. 423, (=*C. atractus* Tomlin, 1937); *nec Conus fusiformis* Pease, 1861, Proc. Zool. Soc. London (1860), p. 398.

Diagnosis: "Shell small for the genus, slender, fusiform in outline. Spire elevated, scalariform, between one-third and one-half the height of the entire shell. Whorls 9 to 9½, including the 3 or 3½ small, smooth, laterally compressed protoconchial turns. First whorl of conch axially costate, the peripheral keel developing only toward the close of the turn. Later whorls of spire strongly angulated at the periphery, which falls a little less than two-thirds the distance from the posterior to the anterior suture. Incremental sculpture vigorous near the posterior suture, especially in the early whorls, becoming more feeble toward the periphery and absent altogether in front of it. Sutures distinct, even a little impressed. Shoulder of body whorl sharply angulated, outlined by the posterior of 20 prominent, subequal rounded spirals separated by interspaces of slightly greater width upon the earlier portion of the whorl but becoming more and more narrow toward the anterior canal, where they are reduced to linear dimensions. Incrementals well developed in the interspiral sulci. Aperture very narrow but little more than half the total height. Outer lip broken; the posterior siphonal notch as revealed by the growth lines only moderately deep. Inner lip smooth, striaght. Anterior canal narrow, obliquely truncate. The type, which is unique, had suffered injury, but the animal has been able to make effective repairs upon its shell." (Gardner, 1937)

Dimensions of holotype: height 13.8 mm, diameter 5.4 mm.

Holotype: USNM 349870.

Type locality: USGS 5633, Yellow River below Oak Grove Bridge, Okaloosa County, Florida (=TU 91).

Occurrence: Oak Grove Sand, Florida; (?) late lower Miocene.

Figured specimen: USNM 220124; height 11.9 mm, diameter 4.4 mm; locality TU 91.

Discussion: Gardner's specific name *C. fusiformis* is preoccupied three times: G. Fischer, 1807; Lamarck, 1810; and Pease, 1861: therefore a new name, *C. vitius,* is here proposed.

The holotype of *C. vitius* remains unique except for one specimen of this small species found in the Tulane University collections. It too has suffered injury and has been repaired. Because of the badly broken lip (*vitius,* Latin for "fault") a dorsal view is shown (pl. 5, fig. 2). Gardner so adequately described her species that no further comment is required.

CONUS SUBMONILIFERUS Gardner
Pl. 5, fig. 3

Conus submoniliferus GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 363, pl. 43, fig. 10.

Diagnosis: "Shell rather large, moderately heavy. Spire low, a little less than one-sixth of the total altitude. Whorls apparently 10 exclusive of the protoconch, which is broken away, the first 5 whorls converging at an angle of approximately 70°, the last 5 at an angle of about 125°; whorls shouldered, those of the earlier turns oblique, and those of the later not far from horizontal. Suture line deeply impressed, following the periphery of the preceeding turn except on the later volutions, where it drops forward a little to reveal the slightly elevated peripheral margin. Spire sculptured with somewhat irregular spiral lirations, 3 on the shoulder of each whorl. Incremental sculpture strong enough to crenulate the spiral minutely. Body whorl feebly inflated in front of the shoulder, so that the maximum diameter does not coincide, as in the majority of the cones, with the outer margin of the shoulder; sculptured on its medial portion, with 7 faint moniliform spirals that grow fainter and, with the exception of the anterior 2 or 3, evanesce before reaching the labrum. Simple, irregular, spiral lirae developed between the 3 or 4 anterior beaded spirals and in front of them, becoming more regular and more crowded toward the anterior extremity. Labrum broken away, probably thin and deeply emarginate at the shoulder. Labium simple, smooth, reinforced at the anterior canal. Canal short, somewhat flaring, truncate." (Gardner, 1937)

Dimensions of holotype: height 40.0± mm, diameter 25.5 mm.

Holotype: USNM 351132.

Type locality: USGS 3732, Dave Adams Mill Creek, Sec. 2, T3N, R21W, Walton County, Florida.

Occurrence: Shoal River Formation, Florida; middle Miocene.

Figured specimen: USNM 351132 (holotype).

Discussion: Gardner (1937, p. 363) stated, "*C. submoniliferus* suggests a *C. sulculus* [from the Chipola Formation] that has been influenced by the prolific and coexistent *C. waltonensis* Aldrich to the extent of developing a faint copy of the *C. waltonensis* sculpture." The writer agrees that *C. submoniliferus* bears a slight resemblance to *C. sulculus* but disagrees with Gardner's contention that *C. submoniliferus* might be the result of hybridization between *C. sulculus* and *C. waltonensis.* As the type of this species is unique perhaps if more specimens were available they would demonstrate the unreliability of placing credence in the presence or absence of basal pustules for definitive separation of species. Although the protoconch is missing the early postnuclear whorls have a "mammilate" appearance, whereas those of *C. sulculus* indicate a more slender nucleus. The suture of *C. submoniliferus* is deeply impressed in contrast to that of *C. sulculus,* which has an adpressed suture. Another notable difference is the color pattern shown under ultraviolet light (compare pl. 1, fig. 10, and pl. 5, fig. 3c).

CONUS WALTONENSIS Aldrich
Pl. 5, figs. 4-8

Conus waltonensis ALDRICH, 1903, Nautilus, v. 16, no. 11, p. 131, 2 text figs.

Conus waltonensis Aldrich. GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 362, pl. 43, figs. 13, 14.

Conus waltonensis anodosus GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 362, pl. 43, fig. 15.

Diagnosis: "Shell medium in size, substance rather thin; spire elevated, with 9 whorls including the apex, which is rather sharp; profile of spire slightly broken by a shoulder just above the suture on each whorl, the sutures impressed, each whorl of the spire concave, and marked by numerous curved lines; periphery sharp; body whorl below the keel in some specimens over one-half smooth, then below this bearing two or three spirals of evenly spaced nodules without any grooves between, gradually changing to rows of nodules on bands between grooves, which are 8 or 10 in number, the nodules fading away as the canal is reached, but in the type specimen the nodules are present over the whole of the smooth part, without, however, any grooves between. Anal notch rather deep and marking the spire with its

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PLATE 5

Figures Page

1. *Conus drezi* S. E. Hoerle, n. sp. (X2) 24
   USNM 220123 (holotype); height 30.0 mm (incomplete), diameter 16.3 mm.
   Locality: TU 69A. Shoal River Fm., middle Miocene.
2. *Conus vitius* S. E. Hoerle, *nom. nov.* (X4) 25
   USNM 220124; height 11.9 mm, diameter 4.4 mm.
   Locality: TU 91. Oak Grove Sand, (?) late lower Miocene.
3. *Conus submoniliferus* Gardner (X1½) 25
   USNM 351132 (holotype); height 40.0± mm, diameter 25.5 mm.
   Locality: USGS 3732. Shoal River Fm., middle Miocene.
4-8. *Conus waltonensis* Aldrich 26
   4. (X8) USNM 220155; height 14.2 mm, diameter 8.0 mm.
   5. (X2) USNM 220126; height 21.4 mm, diameter 12.3 mm.
   6. (X2) USNM 220127; height 19.0 mm, diameter 10.8 mm.
   7. (X2) USNM 220128; height 14.3 mm, diameter 8.2 mm.
      Nos. 5, 6 and 7 show variations in development of pustules.
   8. (X2) USNM 220129; height 20.5 mm, diameter 12.2 mm.
      Locality: All specimens, TU 69A. Shoal River Fm., middle Miocene.
9. *Conus infulatus* S. E. Hoerle, *nom. nov.* (X2) 28
   USNM 371397 (holotype-*C. turbinopsis* Gardner); height 20.0 mm, diameter 12.0 mm.
   Locality: USGS 3856. Shoal River Fm., middle Miocene.

Color patterns as revealed by ultraviolet light.

PLATE 5

former positions; outer lip thin, pillar straight with a very slight twist; aperture straight above, widening near the base." (Aldrich, 1903)

Dimensions of holotype: height 20.0 mm, diameter 12.0 mm.

Holotype: Unknown. Two topotypes: USNM 371398.

Type locality: "Shoal Creek", Walton County, Florida. TU locality 69, Shell Bluff, Shoal River, 5 to 6 miles on dirt road north of Mossyhead, U. S. Highway 90 (NW ¼ Sec. 4, T3N, R21W), Walton County, Florida (here designated).

Occurrence: Shoal River Formation, Florida; middle Miocene.

Figured specimens: Fig. 7, USNM 220128; height 14.3 mm, diameter 8.2 mm. Fig. 6, USNM 220127; height 19.0 mm, diameter 10.8 mm. Fig. 5, USNM 220126; height 21.4 mm, diameter 12.3 mm. Fig. 4, USNM 220125; height 14.2 mm, diameter 8.0 mm. Fig. 8, USNM 220129; height 20.5 mm, diameter 12.2 mm; locality for all specimens TU 69A. Other occurrences: TU locality nos. 69, 91.

Discussion: C. waltonensis, a most prolific species, is confined to the Shoal River Formation. The only variability expressed by this species is in the extent of development of pustules on the final whorl (see pl. 5, figs. 5-7). The diagnostic features, such as a three and one-half whorled nucleus, impressed sutures, concave anal fasciole, shallow anal notch and nearly straight outer lip, remain constant throughout the species.

Gardner (1937, p. 362) created a subspecies of *C. waltonensis, C. w. anodosus,* stating: "The subspecies differs most radically from *C. waltonensis* s. s. in the nondevelopment of spiral rows of pustules upon the body whorl." The development or nondevelopment of pustules on the final whorl is not a major morphological characteristic. Taxonomic distinction should not be based on such a variable feature; therefore, *C. w. anodosus* is placed in synonymy with *C. waltonensis.*

The axial zig-zag color pattern shown under ultraviolet light is unusual (pl. 5, fig. 8), closely resembling that seen on some specimens of the Recent Panamic species, *C. princeps* Linné. However, there is not the remotest relationship between the two species, again demonstrating the fallacy of basing specific determination on color pattern only.

CONUS INFULATUS
S. E. Hoerle, *nom. nov.*
Pl. 5, fig. 9

Conus turbinopsis GARDNER, 1937, U. S. Geol. Surv. Prof. Paper 142-F, p. 361, pl. 43, fig. 12.
Non Conus turbinopsis Deshayes, 1865, Descr. Anim. sans Vert. Bassin Paris, v. 3, p. 425, pl. 100, figs. 10, 11.
Not *Conus turbinopsis* Gardner. PERRILLIAT MONTOYA, 1960, Paleontologia Mexicana, no. 8, p. 27, pl. 4, figs. 3, 4 [=*C. multiliratus* Böse].

Diagnosis: "Shell of medium size, moderately heavy, rather stout, suggesting in outline a rather slender, elongated top. Spire between one-fourth and one-third the height of the entire shell, the sides uniformly converging at an angle of about 90° until the nucleus is reached, when the slope becomes abruptly much more steep. Suture line running directly in front of the periphery of the preceeding whorl, thus making a barely perceptible break in the uniformity of the slope. Whorls 10 or more, including the 1 or 2 small, smooth, laterally compressed protoconchal volutions and an axially costate turn. Periphery developed on the succeeding whorl acute, that of the whorls of the spire barely visible behind the suture line. External sculpture of spire restricted to vigorous incrementals, which mark the successive margins of the posterior siphonal notch. Suture lines distinct but inconspicuous. Body whorl sculptured in front of the periphery with 20 to 25 spiral fillets separated by squarely channeled sulci of rarely more than half the width of the fillets; spirals uniform for the most part in size and spacing but slightly narrower near the periphery and, at the anterior canal, appearing as crowded linear lirations; interspiral sulci finely striated by the incrementals. Shell rather conspicuously constricted and attenuated near the base of the body. Aperture rather narrow, the margins subparallel. Outer lip probably thin but broken in all specimens collected. Posterior siphonal notch moderately deep. Anterior canal narrow, feebly marginate." (Gardner, 1937)

Dimensions of holotype: height 20.0 mm, diameter 12.0 mm.

Holotype: USNM 371397.

Type locality: USGS 3856, five to six miles west-northwest of Mossyhead, Walton County, Florida (=TU 69).

Occurrence: Shoal River Formation, Florida; middle Miocene.

Figured specimen: USNM 371397 (holotype).

Discussion: C. turbinopsis Gardner, 1937, is preoccupied by *C. turbinopsis* Deshayes, 1865, therefore a new name, *C. infulatus,* is proposed for the Shoal River species.

Perrilliat Montoya (1960, p. 27, pl. 4, figs. 3, 4) has figured a specimen of *Conus*

from the Pliocene Agueguexquite Formation of Vera Cruz, Mexico, which she referred to the Shoal River species *C. turbinopsis* Gardner. Her illustration depicts a cone with beaded early whorls and the presence of this feature is confirmed in her description. As there are no beads on the early whorls of Gardner's species, Perrilliat Montoya's shell is undoubtedly *C. multiliratus* Böse, a species that occurs abundantly throughout the Isthmian area. The two species have a similar outline and the ornamentation of the last whorl of both consists of broad bands separated by incrementally striated grooves. The first post-nuclear whorl of *C. infulatus nom. nov.* bears a few axial costae but the remainder of the spire whorls are plain. The two species may easily be separated by this criterion alone.

V. LOCALITY DATA

The following are Tulane University fossil localities. Except as noted all are in the Chipola Formation, Calhoun County, Florida.

69. Shoal River Fm., (type locality), Shell Bluff, Shoal River (NW ¼ Sec. 4, T3N, R21W), about 3½ miles north of Mossyhead, Walton Co., Florida.

69A. Shoal River Fm., first ravine upstream from Shell Bluff, Shoal River (NW ¼ Sec. 4, T3N, R21W), about 3½ miles north of Mossyhead, Walton Co., Florida.

70. Ten Mile Creek, at bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W).

91. Oak Grove Sand, (type locality), west bank of Yellow River, about 100 yards below bridge at Oak Grove, (NE ¼ Sec. 20, T5N, R23W), Okaloosa Co., Florida.

196. Ten Mile Creek, about ¼ mile upstream from bridge of Florida Highway 73 (NE ¼ Sec. 11, T1N, R10W).

456. Ten Mile Creek, about ¼ mile downstream from bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W).

457. West bank of Chipola River, about ½ mile below Ten Mile Creek (SW ¼ Sec. 17, T1N, R9W).

458. East bank of Chipola River, above Farley Creek (SW ¼ Sec. 20, T1N, R9W).

459. East bank of Chipola River, steep bank about 1500 feet above the mouth of Taylor Lake Branch (NW ¼ Sec. 29, T1N, R9W).

546. Ten Mile Creek, about 1½ miles west of Chipola River (NW ¼ Sec. 12, T1N, R10W).

547. West bank of Chipola River, about 2000 feet above Four Mile Creek (SW ¼ Sec. 29, T1N, R9W).

548. West bank of Chipola River (NW ¼ Sec. 29, T1N, R9W).

549. East bank of Chipola River, about ¼ mile below Four Mile Creek (NE ¼ Sec. 32, T1N, R9W).

550. East bank of Chipola River, 1¼ mile below mouth of Ten Mile Creek (NE ¼ Sec. 20, T1N, R9W).

553. East bank of Chipola River at mouth of Farley Creek (SW ¼ Sec. 20, T1N, R9W).

554. East bank of Chipola River at power line crossing (SW ¼ Sec. 17, T1N, R9W).

555. East bank of Chipola River, about 1000 feet above Four Mile Creek (SW ¼ Sec. 29, T1N, R9W).

655. Ten Mile Creek, about 0.1 mile downstream from bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W).

708. At small waterfall on tributary to Ten Mile Creek, south bank, about ¼ mile downstream from bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W).

709. South bank of Ten Mile Creek, about ¼ mile downstream from bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W).

711. West bank of Chipola River, about ¼ mile up from mouth of Farley Creek (SW ¼ Sec. 20, T1N, R9W).

786. Ten Mile Creek, about 50 yards upstream from TU 196 or about ¼ mile upstream from bridge of Florida Highway 73 (NE ¼ Sec. 11, T1N, R10W).

787. Ten Mile Creek, south bank about 1½ miles west of Chipola River (SE ¼ Sec. 12, T1N, R10W).

806. West bank of Chipola River, about one mile below power line crossing (NW ¼ Sec. 20, T1N, R10W).

810. East bank of Chipola River, opposite mouth of Taylor Branch (SW ¼ Sec. 17, T1N, R9W).

817. South side of Ten Mile Creek, large gully on the property of Mr. A. Sexton (1967) (SE ¼ Sec. 12, T1N, R10W).

818. Farley Creek, 0.1 mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).

820b. Farley Creek (lower beds), at bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).

821. Farley Creek, 0.1 mile east of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).

822. Farley Creek, south bank, ¼ mile east of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).

823. Farley Creek, south bank about 2000 ft. east of bridge of Florida Highway 275 (SE ¼ Sec. 21, T1N, R9W).

824. Farley Creek, about ½ mile east of bridge of Florida Highway 275 (SE ¼ Sec. 21, T1N, R9W).
825. Farley Creek at abandoned mill about ¼ mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
826. Farley Creek, about 0.1 mile west of abandoned mill which is ¼ mile west of bridge of Florida Highway 275 (on section line between Sec. 20 and 21, T1N, R9W).
827. Farley Creek, about ½ mile west of bridge of Florida Highway 275 (SE ¼ Sec. 20, T1N, R9W).
828. Farley Creek, just upstream from mouth of unnamed tributary about ¾ mile downstream from bridge of Florida Highway 275 (SE ¼ Sec. 20, T1N, R9W).
830. Ten Mile Creek, at power line crossing about one mile west of Chipola River (SE ¼ Sec. 12, T1N, R10W).
831. Ten Mile Creek [lowest Chipola beds exposed], slightly less than one mile west of Chipola River (SW ¼ Sec. 7, T1N, R9W).
949. Chipola River, west bank, about 0.1 mile below power line (SW ¼ Sec. 17, T1N, R9W).
950. Chipola River, west bank about 2000 ft. above Farley Creek (SW ¼ Sec. 20, T1N, R9W).
951. Ten Mile Creek, about 1¼ miles west of Chipola River (SE ¼ Sec. 12, T1N, R10W).
998. Ten Mile Creek, about 1¼ miles west of Chipola River (SE ¼ Sec. 12, T1N, R10W).
999. Farley Creek, about 1000 yards downstream from bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
1020. Small tributary (not shown on USGS topographic map) on east bank of Chipola River about ½ mile below power line crossing (NE ¼ Sec. 20, T1N, R9W).
1021. Ten Mile Creek, north bank, about 2200 ft. east of bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W).
1047. Chipola River, west bank 0.1 mile below mouth of Farley Creek (SW ¼ Sec. 20, T1N, R9W).
1048. Farley Creek, south bank, about 0.8 mile east of bridge of Florida Highway 275 (NE ¼ Sec. 21, T1N, R9W).
1049. Farley Creek, south bank, about 1.0 mile east of bridge of Florida Highway 275 (NE ¼ Sec. 21, T1N, R9W).
1050. West bank of Chipola River at power line crossing (SW ¼ Sec. 17, T1N, R9W).
1051. Ten Mile Creek, south bank just downstream from large gully on property of Mr. A. Sexton (1967) (SE ¼ Sec. 12, T1N, R10W).
1052. Ten Mile Creek, just up from large dry former creek bed cut off, north bank (SE ¼ Sec. 12, T1N, R10W).
1097. Ten Mile Creek, south bank at a new (1972) cut off meander, 500 yards west of Florida Highway 73 (SE ¼ Sec. 12, T1N, R10W).
1098. Ten Mile Creek, south bank just east of power line crossing (SE ¼ Sec. 12, T1N, R10W).

The following are U. S. Geological Survey Tertiary Fossil localities.

USGS 2646. Oak Grove Sand, Oak Grove, Yellow River, Okaloosa County, Florida.
USGS 3732. Shoal River Fm., Dave Adams Mill Creek (Sec. 2, T3N, R21W), Walton County, Florida.
USGS 3856. Shoal River Fm., 6 miles west-northwest of Mossyhead, Walton County, Florida.
USGS 5633. Oak Grove Sand, Oak Grove, Yellow River, Okaloosa County, Florida.

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ADDENDUM

A NEW SPECIES OF *CONUS* FROM THE CHIPOLA FORMATION

SHIRLEY E. HOERLE*
WEST PALM BEACH, FLORIDA

While the preceding paper was in press another species of Chipola *Conus* was brought to light by the writer's husband. Although the specimen is unique and bears a slight damage anteriorly, its morphological characteristics are so distinct from any other Chipola *Conus* the writer feels it essential to note its occurrence. The shell was collected along Ten Mile Creek, TU 951, in the basal beds of the Chipola Formation. A number of unusual and unexpected genera and species have appeared at this locality, one example being *"Ranella" poppelacki* Hörnes (see E. H. Vokes, 1974, p. 96).

CONUS SEXTONI S. E. Hoerle, n. sp.
Text fig. 1

Diagnosis: Shell low spired; slender; periphery about one-fourth distance in front of shoulder; tapering anteriorly with a suggestion of a slight twist to the left. Adult specimen consisting of two and one-half rounded nuclear whorls and seven teleoconch whorls. Sutures distinct, slightly impressed. Summits of early post-nuclear whorls flat, those of later whorls convex with an adaxial slope, forming a slight concavity in front of suture. Whorls ornamented by prominent, but not crowded, moderately arched growth lines. Anal notch shallow; outer lip nearly straight. Sculpture of last whorl consisting of broad, flat bands separated by narrow, incrementally striated grooves; growth lines prominent, giving the shell an axially roughened appearance.

Dimensions of holotype: height 19.0 mm (incomplete), diameter 9.2 mm.

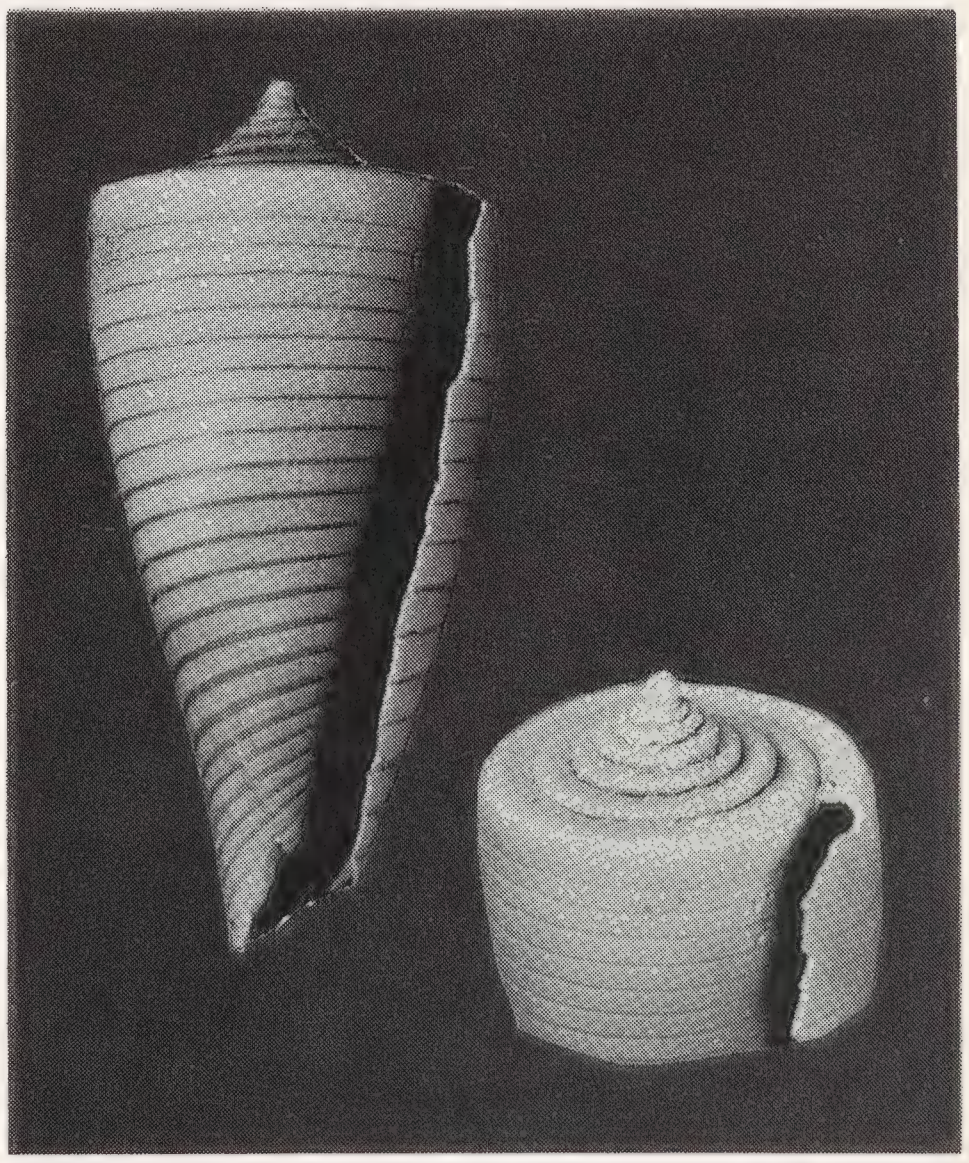
Holotype: USNM 647645.

Type locality: TU 951, Ten Mile Creek, about 1¼ miles west of Chipola River (SE ¼ Sec. 12, T1N, R10W), Calhoun County, Florida.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimen: USNM 647645. (holotype).

Discussion: C. sextoni is represented only by the type specimen and does not appear to



Text figure 1. *Conus sextoni* S. E. Hoerle, n. sp. Holotype, USNM 647645.

*Research Associate, Paleontological Research Institution, Ithaca, New York; Associate, Department of Earth Sciences, Tulane University.

be allied to any other *Conus* species from the Chipola Formation. It cannot definitely be stated at this time if the bands and narrow grooves, completely covering the final whorl, are a constant feature of this species as, generally, the extent of ornamentation of the last whorl is a variable factor, *e.g., C. chipolanus* Dall. The two and one-half whorl nucleus, the lack of ornamentation of the early whorls and the uniquely formed summits of the spire whorls easily differentiate this species from other *Conus* of the Alum Bluff Group. The only other fossil cone to which this new species bears a resemblance, and only superficially, is *C. cruzianus* Dall, 1890, from the Pliocene limestone of the "Island of Santa Cruz, West Indies" [St. Croix, U.S. Virgin Islands]. The one feature *C. sextoni* and *C. cruzianus* have in common is a slight channel in front of the suture. The ornamentation on the last whorl of *C. cruzianus* consists of rounded, finely striated cords, the posterior ones medially sulcated, as contrasted to the bands and grooves of *C. sextoni.*

A Recent Caribbean species, *C. granulatus* Linné, 1758, has the final whorl sculpture similar to *C. sextoni* but the spire characteristics are entirely different. Treatment failed to reveal any color pattern and so it must be assumed that in life the shell was unpatterned, unlike *C. granulatus,* which has strong shoulder markings.

This shell is named in honor of Mr. Cecil Sexton, Altha, Florida, who has generously permitted workers to collect at TU 951, which is located on his property.

LITERATURE CITED

VOKES, E. H., 1974, Notes on the fauna of the Chipola Formation — XV. On the occurrence of *"Ranella" poppelacki* Hörnes, a gastropod of uncertain affinities: Tulane Stud. Geol. Paleont., v. 11, no 2, p. 96-98, text fig. 1, 2.

REVIEWS

GEOGRAPHICAL VARIATIONS IN COASTAL DEVELOPMENT, by J. L. Davies. Published by Hafner Publishing Company, New York, 1973, viii + 204 pp., 130 figs.

This is an investigation of how the morphological development of coastal areas varies from one part of the world to another which attempts to isolate the factors causing such variations. An attempt is made to recognize broad patterns in coastal processes on a global scale. The claim is made that climate is a major factor which modifies the effects of geological structure and the influence of lithology. Three broad latitudinal zones are recognized from which conceptual models of shoreline evolution can be generated, low-latitude, mid-latitude, and high-latitude. The differing characteristics of each are enumerated.

DEPOSITIONAL SEDIMENTARY ENVIRONMENTS, by Hans-Erich Reineck and Indra Bir Singh. Published by Springer-Verlag, New York, Heidelberg, and Berlin, 1973, xvi + 439 pp., 579 figs., $41.60

This volume is intended as a compilation of the information needed to reconstruct ancient depositional environments. Though it is not a textbook on sedimentology and does not include methods of study, it is a comprehensive review of those sedimentary features considered by the authors to be significant and useful in environmental interpretation. The book is profusely illustrated. It is well and clearly written and deserves a place on the shelf of every active geologist.

—H.C.S.

NOTES ON CANCELLARIIDAE (MOLLUSCA: GASTROPODA) – III

RICHARD E. PETIT*
NORTH MYRTLE BEACH, SOUTH CAROLINA

ABSTRACT

This paper is the third in a series devoted to the gastropod family Cancellariidae. In this paper seven new species are described and illustrated. Of the new taxa, two are from the Tertiary of Panamá, one from the Tertiary of Virginia. One Recent species is from the Galápagos Islands, one is from West Africa, and two are from the tropical western Atlantic.

Agatrix epomis (Woodring, 1928), originally described from the Bowden Formation of Jamaica, is reported from the Recent fauna of Venezuela.

A possible deep-water form of the shallow water species *Cancellaria reticulata* (Linné, 1767) is illustrated and discussed. The taxon *Voluta cancellata* Linné, 1767, is also discussed. In addition, *Cancellaria dalli* Bartsch, 1915, is shown to be a synonym of *Trigonostoma bullatum* (Sowerby, 1832), and there is a short discussion of the genus *Admetula* and its distinction from *Agatrix*.

ACKNOWLEDGEMENTS

The writer is indebted to Axel A. Olsson, Coral Gables, Florida, for making known the existence of the Western Atlantic Recent species treated herein, and to Gilbert L. Voss and Frederick M. Bayer of the Division of Biology and Living Resources of the Rosentiel School of Marine and Atmospheric Sciences, University of Miami, for permitting study of these specimens.

Loan of collections of the Geology Department of Tulane University has greatly facilitated the study of this family, and the advice and assistance of Emily H. Vokes has been invaluable.

Expressions of appreciation are also due to Joseph Rosewater and Harald A. Rehder of the National Museum of Natural History, Washington, D.C., and to C. P. Nuttall of the Geology Department, British Museum (Natural History), London, for assistance in using their libraries and collections during visits to their respective institutions.

For contributing specimens for study, the writer is indebted to Carl C. Withrow, St. Petersburg, Florida; T. Walley Williams, Morgantown, West Virginia; and Mrs. Jacqueline DeRoy, Isla Santa Cruz, Galápagos Islands, Ecuador.

The continued assistance of Druid Wilson, U.S. Geological Survey, Washington, D.C., is gratefully acknowledged.

*Research Associate, Paleontological Research Institution, Ithaca, New York.

SYSTEMATICS

The family Cancellariidae traditionally has been placed in the Superfamily Volutacea, usually near the Mitridae and Volutidae. In a recent paper, Olsson (1970) has shown that the Cancellariidae possess an entirely different type of radula than any previously known, and he has proposed the new order Nematoglossa. Ponder (1973, p. 323) states that division on the ordinal level is not necessary, but introduced the superfamilial taxon Cancellariacea, which has been subsequently adopted by Keen and Coan (1974, p. 138). Suprageneric classification is beyond the scope of this paper, and mention is made of this subject only to call attention to Olsson's important work.

Genus CANCELLARIA Lamarck, 1799

Cancellaria LAMARCK, 1799, Mém. Soc. Hist. Nat. Paris, v. 1, p. 71.
Type, by monotypy, *Voluta reticulata* Linné, 1767. Recent, North Carolina to Brasil.

CANCELLARIA cf. RETICULATA (Linné, 1767)

Plate 1, fig. 1

Voluta reticulata LINNÉ, 1767, Systema Naturae, Ed. 12, p. 1190, no. 408.

Two specimens of a large *Cancellaria* were taken by the R/V *Gerda* at depths of 40-47

and 95 meters off of the Florida Keys. These shells are much more attenuate than shallow-water specimens of *C. reticulata,* and have much finer sculpture. In shape they approach the Tertiary *C. conradiana* Dall.

Cancellaria conradiana was described by Dall (1890, p. 42) without locality, but it is evident that he was describing a fossil and Schuchert (1905, p. 124) subsequently noted that the holotype was from the Caloosahatchee River at Fort Thompson. Later (Dall, 1892, p. 211), the name appears in a species list of the Waccamaw fauna, where it is stated as being known only from the Pliocene.

The first appearance of the name *C. conradiana* was as a nude name (Dall, 1889, p. 104) where it is listed in the Recent fauna of west Florida and in the Pliocene. *Cancellaria conradiana* Dall was listed by Johnson (1934, p. 144) as a Recent species. As mentioned by Gardner (1948, p. 264) there are no Recent specimens of *C. conradiana* in the U. S. National Museum. Recent searches for such specimens by Mr. Druid Wilson, U. S. Geological Survey (personal communication), and by the writer, confirm Dr. Gardner's statement. No Recent specimens of *C. conradiana* are known to the writer, although it is a common fossil in the late Tertiary of the Carolinas and Florida. The Recent specimen figured as *Cancellaria conradiana* by Perry (1940, pl. 39, fig. 276) and by Perry and Schwengel (1955, pl. 39, fig. 276) appears to be a rather high spired, albinistic *C. reticulata,* with typical rough surface.

The two Recent specimens under discussion have a slightly smoother surface than the rough *C. reticulata,* but are more strongly sculptured than *C. conradiana.* Although the height/width ratio of these two specimens is comparable to that cited by Dall for *C. conradiana,* they are less attenuate than examples of *C. conradiana* of equal height in the writer's collection from the Waccamaw Formation of South Carolina. The Recent subspecies *C. reticulata adelae* Pilsbry, 1940, while smooth, has the form of typical *C. reticulata.*

These two specimens may represent a deep-water form of *C. reticulata,* although if enough specimens were available for study it might show that they represent a different species. Definitive identification of these two specimens must await availability of additional material.

Figured specimen: Rosentiel School of Marine and Atmospheric Science no. 30-7525; height 42.5 mm, diameter 22.1 mm; locality *Gerda* Station G-756, Florida Keys, Florida.

Subgenus BIVETIELLA Wenz, 1943

Bivetiella WENZ, Handbuch Paläozoologie, v. 6, Gastropoda, p. 1356.

Type, by original designation, *Cancellaria similis* Sowerby, 1833. Recent, West Africa.

CANCELLARIA (BIVETIELLA) CANCELLATA (Linné, 1767)

Murex scabriculus LINNÉ, 1758, Systema Naturae, ed. 10, p. 751, no. 473.

Voluta cancellata LINNÉ, 1767, Systema Naturae, ed. 12, p. 1191, no. 413.

This well known species was first described by Linné in 1767. In the 12th Edition of the *Systema Naturae* he changed the placement of the species from *Murex* to *Voluta.* As he was also moving his *Buccinum scabriculum* of the 10th Edition to *Voluta* in the 12th Edition, he changed the name of *Murex scabriculus* to *Voluta cancellata* to avoid homonymy.

Under the rules of nomenclature in effect during recent years, the taxon *scabriculus* would be available in *Cancellaria.* A search of the literature reveals only two uses of the name, one of which is in a list (H. & A. Adams, 1854, p. 276), which also includes *Cancellaria cancellata.* The only clear use of *scabriculus* as the proper name for this species is by Pallary (1900, p. 259), who cites the name as *scabriusculus* instead of *scabricula.* This spelling error originated with Linné (1767, p. 1191) who referred back to *"Murex scabriusculus"* in his discussion of *Voluta cancellata.*

A history of the species is given at length by Dodge (1955, pp. 99-101), but he does not mention the availability of *scabricula* to replace *cancellata.* Fortunately, the specific name *cancellata* can be retained under the new I.C.Z.N. rule (Article 59i), which states that a junior secondary homonym rejected before 1961 is permanently rejected. Publi-

cation of this rule in 1973 makes a previously planned petition to the I.C.Z.N. for retention of *C. cancellata* unnecessary.

Subgenus SVELTIA Jousseaume, 1887

Sveltia JOUSSEAUME, 1887, Le Naturaliste, ser. 2, v. 1, fasc. 18, p. 214.

Type, by original designation, "*Sveltia varicosa* Brocc." (= *Voluta varricosa* Brocchi, 1814). Pliocene, Italy.

CANCELLARIA (SVELTIA) GLADIATOR n. sp.

Plate 1, fig. 2

Diagnosis: Protoconch smooth, helicoidal, composed of just over three whorls. Protoconch eroded on most adult specimens, but prominent on juveniles. Body whorl large, forming over two-thirds of total length of shell; the whorls well shouldered, with long spines at regular intervals. Sculpture consisting of five to seven well-formed varices, which are produced into long, open spines at the shoulder angle, with smaller but prominent spines on the spiral ridge immediately below the shoulder. The posterior one-third of the body whorl devoid of sculpture except for the spiral cord at the shoulder. The anterior portion of the body whorl consisting of about seven widely spaced spiral cords, which produce short spines at the varices. Aperture ovate, the outer lip thin, the spiral sculpture in evidence being marked by corresponding depressions on the interior. The columella with three prominent sharply descending folds, the posterior one being larger and the anterior one forming a keel bordering the rounded siphonal canal. A moderately heavy parietal callus present on adult specimens. The shell thin for its size, and translucent.

Dimensions of holotype: height 52.1 mm; diameter 25.4 mm (exclusive of shoulder spines); diameter 39.6 mm (inclusive of shoulder spines).

Holotype: USNM 760634.

Type locality: Southern coast of Academy Bay, Isla Santa Cruz, Galápagos Islands, 200 meters.

Occurrence: Recent, known only from the Galápagos Islands.

Figured specimen: USNM 760634 (holotype).

Discussion: Although this species is spinose in much the same manner as the type of *Calcarata* Jousseaume, 1887, other characters relate it more closely to *Sveltia,* which is known from the Tertiary of Europe and Ecuador, and Recent off of West Africa and the Pacific coast of Central America. Placement in this subgenus is tenative pending a complete review of the family.

Cancellaria (Sveltia) gladiator is closely related to *C. centrota* Dall, 1896, but differs from that species in its greater development of shoulder spines, and the presence of a second row of spines on the first spiral ridge anterior to the shoulder. These spines are open in *C. gladiator,* but in *C. centrota* they are largely closed. Also, *C. centrota* is a much heavier and thicker shell. *Cancellaria gladiator* is also closely allied to *C. trochilia* Olsson, 1964, from the Neogene of Ecuador, but differs from that species by having longer, more delicate spines, and by the presence of fewer and stronger spiral cords. The large size and long spines, as well as the second row of spines, easily separates *C. gladiator* from the Recent Panamic Pacific *C. centrota* Dall.

All known specimens were dredged by Mrs. Jacqueline DeRoy, Isla Santa Cruz, Galápagos Islands. Paratypes have been distributed to other interested institutions.

Genus OLSSONELLA Petit, 1970

Olssonella PETIT, 1970, Tulane Stud. Geol. Paleont., v. 8, no. 2, p. 83.

Type, by original designation, *Cancellaria smithii* Dall, 1888. Recent, tropical Western Atlantic.

OLSSONELLA PANAMICA n. sp.

Plate 2, fig. 1

Diagnosis: Shell scalate. Protoconch smooth, of about two and one-half whorls. Body whorl, which comprises one-half of total shell length, sculptured with six to eight strongly arched axial ribs crossed by about twelve spiral cords, very weak in the interspaces but strong where they cross the axial ribs. Shoulder well rounded with impressed suture. Aperture narrowly ovate with about nine or ten strong lirae on interior of outer lip. Columella with two folds and a swelling near the base, which might appear to be a third fold. Umbilicus narrow and deep, bounded by a rounded umbilical ridge.

Dimensions of holotype: height 12.5 mm; diameter 7.7 mm.

Holotype: USNM 220090.

Type locality: TU 757, hillslope on south side of Transisthmanian Highway at junction of road to Refineria Panamá, just east of Cativa, Colon, Panamá. Gatun Formation, Pliocene.*

Occurrence: Known only from the Gatun Formation, Panamá.

Figured specimen: USNM 220090 (holotype).

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*Many of the Neogene formations of the western Atlantic region are being recognized as younger than formerly thought, on the basis of planktonic foraminifera and calcareous nannofossil dating. Thus a number of the formations that have been cited as middle and upper Miocene are now considered to be Pliocene or Pleistocene in age.

Discussion: This is the species listed by Woodring (1970, p. 345), from fragments, as *Trigonostoma* cf. *T. scalatella* (Guppy). Of the two specimens collected by this writer, one is complete and the other lacks only the final portion of the body whorl. Unfortunately the perfect specimen was broken during cleaning, but it was possible to cement it back together with loss of only a small piece of the anterior portion of the lip. The type has been deposited in the USNM as indicated, and the other specimen, almost identical in size, remains in the writer's collection. Another paratype, a complete adult specimen, but slightly worn and fractured, was collected by Drs. H. E. and E. H. Vokes and is also in the USNM.

This new species is very close to *O. campbelli* (Shasky) of the Recent Panamic Pacific fauna, but differs from that species in being much less tabulate, as the sutures are not nearly so impressed, and it therefore lacks the recurved shoulder of *O. campbelli. Olssonella panamica* also lacks the secondary spiral cords that are present in the Recent species and in the closely related *O. scalatella* (Guppy) of the Bowden Formation of Jamaica.

In addition to the specimens discussed, a portion of another specimen consisting of one complete whorl was collected at a nearby locality (TU 958) by Drs. H. E. and E. H. Vokes. This fragmentary specimen is in the Tulane University collection.

OLSSONELLA WILLIAMSI n. sp.
Plate 2, fig. 2

Diagnosis: Shell scalate. Protoconch unknown, first postnuclear whorl smooth, rounded. Shell consisting of about six whorls, which are strongly shouldered with a deep suture. Sculpture of strong rounded axial ribs, numbering seven on the body whorl, crossed by about fifteen evenly spaced spiral cords, which rise over the axials. Intermediate weaker cords between some of the spirals. Aperture roughly trigonal, being rounded at the shoulder. Outer lip rounded with about nine interior lirations. Columella straight, with two folds, the posterior one being stronger and the anterior one descending. Umbilicus narrow and deep.

Dimensions of holotype: height 17.4 mm; diameter 8.4 mm.

Holotype: USNM 220091.

Type locality: TU locality 613, "Rice's Pit," Hampton, Virginia. Yorktown Formation, Pliocene.

Occurrence: Known only from the type locality.

Figured specimen: USNM 220091 (holotype).

Discussion: This species is closest to *Olssonella campbelli* (Shasky, 1961) from the Recent Panamic Pacific fauna, and differs from that species by the narrower,

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PLATE 1

Figures — Page

1. *Cancellaria* cf. *reticulata* (Linné) (X1½) 33
   Rosenstiel School of Marine and Atmospheric Science 30-7525; height 42.7 mm, diameter 22.1 mm.
   Locality: Florida Keys, Recent.
2. *Cancellaria (Sveltia) gladiator* R. E. Petit, n. sp. (X1) 35
   USNM 760634 (holotype); height 52.1 mm; diameter 25.4 mm (exclusive of shoulder spines; diameter 39.6 mm (inclusive of shoulder spines).
   Locality: Academy Bay, Isla Santa Cruz, Galápagos Islands, 200 meters. Recent.
3. *Agatrix epomis* (Woodring) (X3) 38
   USNM 747976; height 14.6 mm, diameter 8.5 mm.
   Locality: *Pillsbury* Station P-734, Venezuela. Recent.
4. *Admetula bayeri* R. E. Petit, n. sp. (X2) 38
   USNM 747977 (holotype); height 19.4 mm, diameter 13.5 mm.
   Locality: *Gerda* Station G-952, off Yucatán Peninsula, Mexico. Recent.
5. *Admetula vossi* R. E. Petit, n. sp. (X3) 39
   USNM 747978 (holotype; height 12.8 mm, diameter 8.5 mm.
   Locality: *Gerda* Station G-524, Bahamas, Recent.

All specimens were whitened before photographing to show details of sculpture.

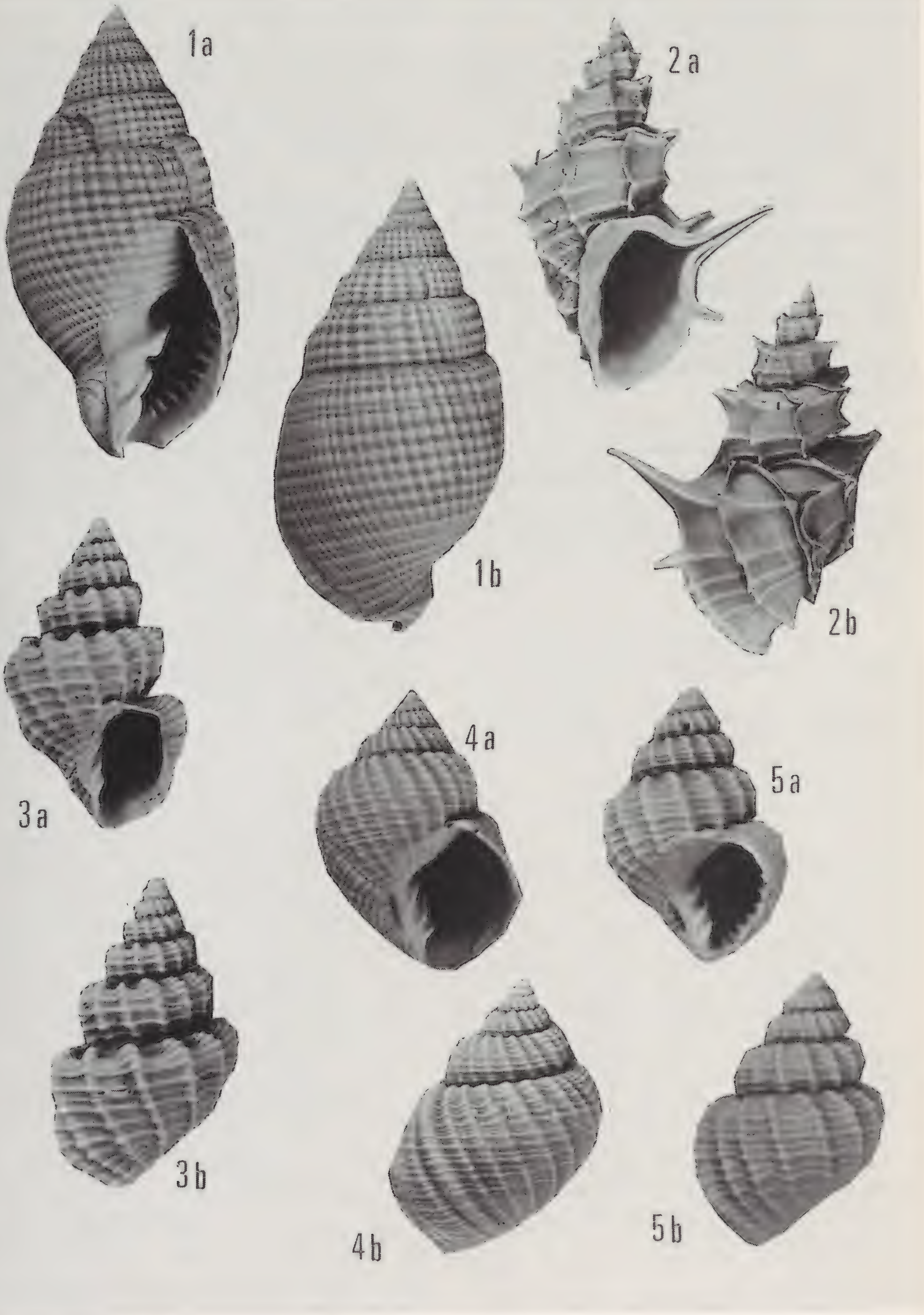

PLATE 1

less open umbilicus and more numerous, weaker axial ribs.

It should be noted that on this specimen there are several incised lines on the columella between the top of the aperture and the posterior fold. These grooves obviously have been made by some external agency, and have not been considered in the description of the species. Irregular grooves also appear well inside the aperture on the outer part of the body whorl, possibly made by the same agency responsible for the columella grooves. Similar grooves have been observed on both Recent and fossil gastropods, but this writer has been unable to determine the exact cause.

The unique shell on which this description is based was collected by Dr. T. Walley Williams, Morgantown, West Virginia, who made the specimen available for study and description, and who permitted the specimen to be deposited in the United States National Museum.

Genus AGATRIX Petit, 1967

Agatrix PETIT, 1967, Tulane Stud. Geol., v. 5, no. 4, p. 218.

Type, by original designation, *Trigonostoma agassizii* Dall, 1889. Recent, North Carolina to Gulf of Mexico.

AGATRIX EPOMIS (Woodring, 1928)
Plate 1, fig. 3

Tribia epomis WOODRING, 1928, Carnegie Inst. Washington, Publ. 385, p. 223, pl. 12, fig. 10.

Diagnosis: Shell high spired, tabulate. Protoconch smooth, of about one and one-half whorls. Postnuclear whorls six in number, strongly shouldered. Sculpture consisting of axial riblets, ten on the body whorl, overridden by thin, sharp spiral cords set between smooth interspaces, forming a cancellate appearance. A well-defined shoulder, smooth near the suture. Spiral cords, numbering about fourteen, beginning on the shoulder nodes, with five of the spiral cords being crowded onto the shoulder nodes. The remaining spiral cords are evenly spaced. Aperture ovate, the outer lip thin. Slightly concave columells with three folds, the anterior one forming a keel bordering the siphonal canal. Umbilicus chink-like.

Dimensions of holotype: height 11.8 mm, diameter 7.3 mm.

Holotype: USNM 135418.

Type locality: Bowden, Jamaica (= TU 705).

Occurrence: Bowden Formation, Jamaica (Pleistocene) and off the coast of Venezuela (Recent).

Figured specimen: USNM 747976; height 14.6 mm, diameter 8.5 mm; *Pillsbury* Station P-734, off coast of Venezuela, 11°01'N, 65°36'W, 60-68 meters.

Discussion: Originally described from the Bowden Formation, this is the first report of this species in the Recent fauna. The figured specimen agrees in all details with the type lot, which consists of three specimens. *Agatrix epomis* differs from *A. agassizii* in having a smooth area between the shoulder nodes and the suture, in having the suture less deeply impressed, and in having spiral cords more widely spaced with resultant wide interspaces.

Genus ADMETULA Cossmann, 1889

Admetula COSSMANN, 1889, Ann. Soc. Roy. Malac. Belg., v. 24, p. 228.

Type, by original designation, *Cancellaria evulsa* (Solander), (= *Buccinum evulsa* Solander, 1766). Eocene, England.

ADMETULA BAYERI n. sp.
Plate 1, fig. 4

Diagnosis: Shell large for the genus, white with porcellaneous shine on interior of outer lip and columellar area. Protoconch smooth, consisting of about one and one-half whorls. Postnuclear whorls numbering about six, rapidly enlarging to a somewhat naticoid shape. Periostracum fine and rather thinkly matted, but basic sculpture visible through the periostracum. Sculpture of regularly spaced, close set, rounded axial ribs numbering about sixteen on the body whorl, crossed by evenly spaced spiral cords, which do not form nodes as they cross the axials. Spiral cords numbering about eight on the penultimate whorl. Shoulders rounded, suture impressed. Outer lip rounded and ventricose, a slight stromboid notch appearing below the center of the lip, but which cannot be detected in earlier growth lines. Columella inclined, with two strong descending folds and a third fold that forms a keel bordering the siphonal canal.

Dimensions of holotype: height 19.4 mm, diameter 13.5 mm.

Holotype: USNM 747977.

Type locality: *Gerda* Station G-952, off Yucatán Peninsula, Mexico, 21°02'N, 86°26'W, 585-591 meters.

Occurrence: Recent, Gulf of Mexico, known only from type locality.

Figured specimen: USNM 747977 (holotype).

Discussion: This and the following species are assigned to the genus *Admetula,* even though the type of genus is an Eocene species from England. Examination of the type specimen of *Admetula evulsa* (Solander) in the British Museum (Natural History), and subsequent procurement of additional specimens for comparative study have enabled the writer to make this assign-

ment. The type of the genus is much like the species described above, with the same rounded outline and a strongly inclined columella with identical fold structure. *Admetula evulsa* differs primarily in having rounded varices, whereas none of the Recent species being assigned to *Admetula* have varices.

Agatrix differs from *Admetula* in being turreted, having a proportionately narrower aperture, and in having a less concave columella. Adult specimens of *Agatrix* develop a thin parietal shield. Only two species of *Agatrix* have been live-collected with periostracum intact, but in both of these (*A. agassizi* Dall and *A. strongi* Shasky) the periostracum is tufted at the shoulders, a feature not present in *Admetula bayeri,* which has a smooth, evenly distributed periostracum. The recently described *Agatrix deroyae* Petit, 1970, was incorrectly placed, and is an *Admetula* as the genus is now interpreted by the writer.

This new species is named for Dr. Frederick M. Bayer, Division of Biology and Living Resources of the Rosenstiel School of Marine and Atmospheric Sciences. University of Miami.

ADMETULA VOSSI n. sp.
Plate 1, fig. 5

Diagnosis: Protoconch unknown; postnuclear whorls about six in number. Whorls rounded, body whorl large. Sculpture consisting of axial riblets, about twelve on the body whorl, which are crossed by narrow, evenly spaced spiral cords forming small nodes on the summit of the ribs, there being about seventeen spiral cords between the suture and the anterior canal. Weaker intermediate spirals sometimes occuring between the primary spiral cords. Aperture semi-ovate, with about eight lirations within the outer lip. Siphonal canal well rounded, but not produced nor forming a fasciole. Three columellar plaits, on an inclined pillar, the anterior one forming a keel bordering the siphonal canal.

Dimensions of holotype: height 12.8 mm, diameter 8.5 mm.

Holotype: USNM 747978.

Type locality: *Gerda* Station G-524, south of Grand Bahama Island, Bahamas, 26°17'N, 78°41'W, 622-695 meters.

Occurrence: Recent, Bahamas, known only from type locality.

Figured specimen: USNM 747978 (holotype).

Discussion: This new species is known only from a single incomplete specimen. It is remarkably similar to *Admetula deroyae* (Petit, 1970) from the Galápagos Islands, which is also a deep-water species. This new species differs from *A. deroyae* in having rounded shoulders, whereas *A. deroyae* has slightly shouldered whorls. Also, the spiral cords in *A. vossi* are weaker than the spiral cords in *A. deroyae,* and do not become as enlarged where they cross the axial ribs. *Admetula zapoteca* (Böse, 1910) from the Pliocene of Tehuantepec is quite similar, but is more attenuate.

This species is named for Dr. Gilbert L. Voss, Division of Biology and Living Resources of the Rosenstiel School of Marine and Atmospheric Sciences, University of Miami.

Genus TRIGONAPHERA Iredale, 1936

Trigonaphera IREDALE, 1936, Rec. Aust. Mus., v. 19, no. 5, p. 319.

Type by original designation, *Trigonostoma vinnulum* Iredale, 1925. Recent Australia.

TRIGONAPHERA WITHROWI n. sp.
Plate 2, fig. 3

Diagnosis: Nucleus smooth, naticoid, of about two whorls. The first post-nuclear whorl with close-spaced spiral cords, which are later crossed by axial ribs. Postnuclear whorls number about five. Body whorl with strongly defined spiral cords, about six of which are crowded on the shoulder. Anterior to the shoulder about eight strong spiral cords, with three secondary spirals crowded in the interspaces. Body whorl with eight strong rounded axial ribs crossed by the spirals. At the shoulder these ribs are flattened and form a sharp ridge from the shoulder to the suture. Interspaces between these ribs concave and bearing fine spirals. Outer lip smooth, with strong definition in the interior. A smooth notch present just inside the shoulder, with three plications above and ten below, all of which extend well inside the shell. Columella slightly concave with three folds, the anterior one forming the top of the short, inclined siphonal canal. Columella slightly rugose. Small, deep umbilicus bordered by a strong umbilical ridge. Shell cream colored with reddish-brown maculations on the concave interspaces above the shoulder. Nucleus and first postnuclear whorls brownish.

Dimensions of holotype: height 21.4 mm; diameter 15.7 mm.

Holotype: USNM 760635.

Type locality: Off Senegal, West Africa, 25 meters.

Occurrence: Recent, known only from the type locality.

Figured specimen: USNM 760635 (holotype).

Discussion: The off-shore fauna of northwest Africa is still relatively little known. This specimen was obtained by Mr. C. C.

Withrow, St. Petersburg, Flordia, from a correspondent, Mr. I. Marche-Marchad. Correspondence to Mr. Marche-Marchad concerning this species remains unanswered. This new species has been named for Mr. Withrow, a well known collector and student of mollusca, who has made the specimen available for study and who has donated the holotype to the United States National Museum.

Nicklès (1950, p. 116, fig. 212) figures a West African cancellariid as *Cancellaria rigida* Sowerby. His illustration is of a shell quite distinct from the one under discussion, and appears to be a *Bivetopsia. Cancellaria rigida* Sowerby is also listed from West Africa by Marche-Marchad (1958, p. 31).

G. B. Sowerby I described *Cancellaria rigida* (1832, p. 53; 1833, p. 7, fig. 41) from a single specimen collected by Hugh Cuming, from Central America. The figure in the *Conchological Illustrations* is not good, and the type cannot be located. Two syntypes have been located in the British Museum (Natural History), catalog number BM(NH) 1964445. As noted by Keen (1958, p. 442; 1971, p. 658) and others, *C. rigida* Sowerby is a synonym of the rather variable *Cancellaria goniostoma* G. B. Sowerby I, 1832. It should be noted that all of the species described in Sowerby's 1832 paper were collected by Cuming on the Pacific coast of Central America.

Cancellaria costata "Gray" G. B. Sowerby I (1833, p. 7, fig. 42) was described without locality, and the figure could represent *T. withrowi.* However, the name is preoccupied by *Cancellaria costata* G. B. Sowerby I, 1821, *Genera of Recent and Fossil Shells,* no. 5, *Cancellaria,* fig. 2 (= *Voluta cancellata* Linné). G. B. Sowerby II (1849, pp. 456-7) figured *C. costata* and gave as locality "from the sands in the River Gambia." He also stated that he did not think *C. rigida* to be distinct. His figure 103, listed on plate explanation as "*costata* var. *rigida,*" does not resemble the original figure of *C. rigida* in the *Conchological Illustrations,* and it is evident that even at this early date that there was a misunderstanding about the species involved.

To summarize, *Cancellaria rigida* G. B. Sowerby I, 1832, is a synonym of *C. goniostoma* G. B. Sowerby I, 1832. *Cancellaria costata* "Gray" G. B. Sowerby I, 1833, is a junior primary homonym of *C. costata* G. B. Sowerby I, 1821, which in turn is an objective synonym of *Cancellaria cancellata* (Linne). The specimens figured in *Conchological Illustrations* (figure 42) and in the *Thesaurus Conchyliorum* (figures 60, 61, 103) could not be located at the British Museum (Natural History) by the writer in 1968.

Trigonaphera withrowi seems most closely related to the Indo-Pacific *T. bicolor*

PLATE 2

Figures Page

1. *Olssonella panamica* R. E. Petit, n. sp. (X3) 35
USNM 220090 (holotype); height 12.5 mm; diameter 7.7 mm.
Locality: TU 757. Gatun Formation, Cativa, Colon, Panamá; Pliocene.

2. *Olssonella williamsi* R. E. Petit, n. sp. (X3) 36
USNM 220091 (holotype); height 17.4 mm; diameter 8.4 mm.
Locality: TU 613. Hampton, Virginia. Yorktown Formation, Pliocene.

3. *Trigonaphera withrowi* R. E. Petit, n. sp. (X2) 39
USNM 760635 (holotype; height 21.4 mm; diameter 15.7 mm.
Locality: Off Senegal, West Africa, 25 meters. Recent.

4. *Trigonostoma (Ventrilia) sacellum* R. E. Petit, n. sp. (X2) 42
USNM 220092 (holotype); height 25.5 mm; diameter 18.3 mm.
Locality: TU 958. Gatun Formation, Cativa, Colon, Panamá; Pliocene.

5. *Trigonostoma (Ventrilia) senarium* Petit and Hoerle, n. sp. (X1½) 44
USNM 220085 (holotype); height 34.1 mm; diameter 26.3mm.
Locality: TU 1000. Pinecrest Beds, Sarasota County, Florida; Pliocene.

All specimens were whitened before photographing to show details of sculpture.

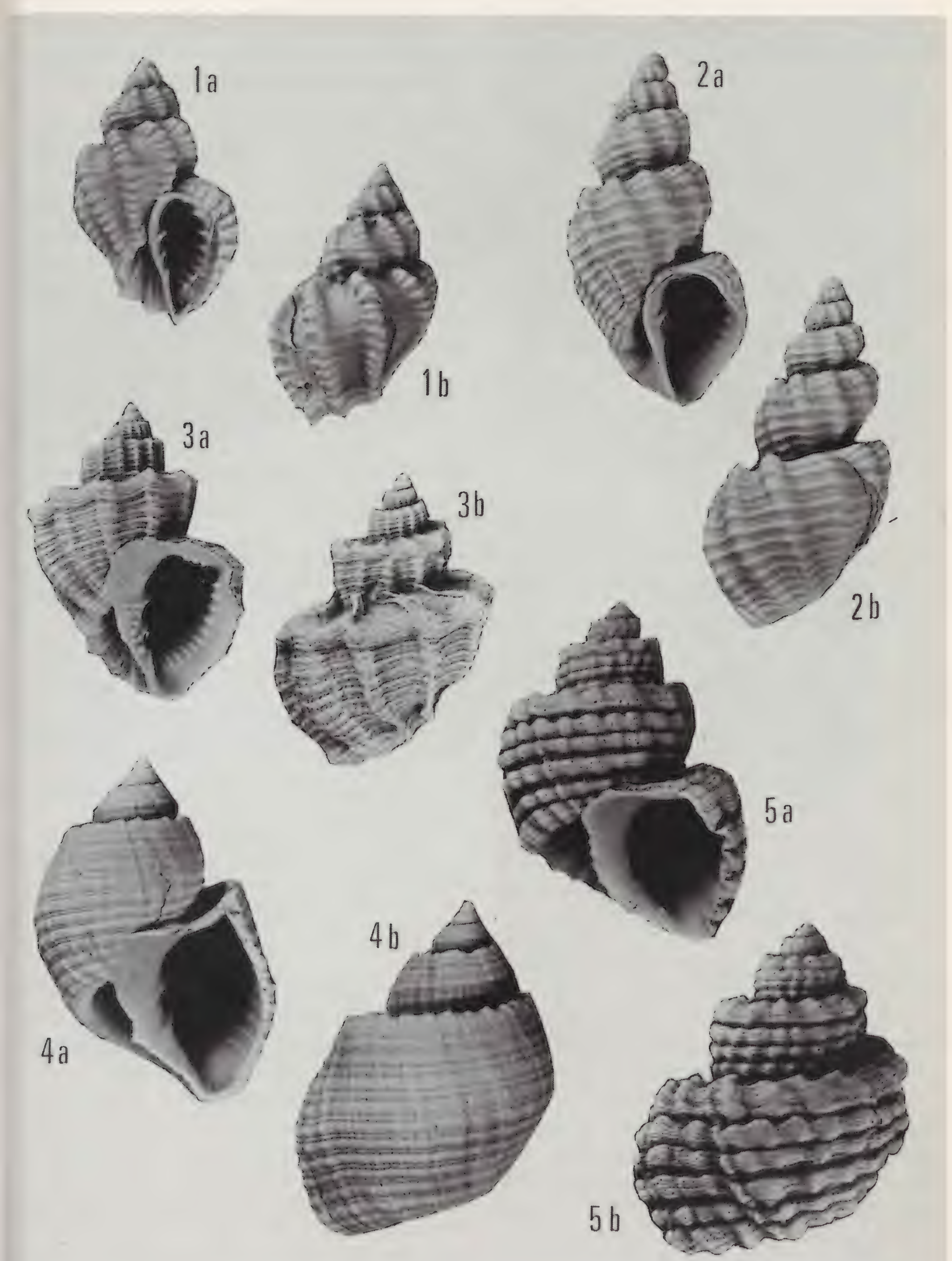

PLATE 2

(Hinds, 1843). It differs from that species in having much stronger spiral sculpture and a much smaller umbilicus. Placement in *Trigonaphera* is tentative pending a complete review of the genus.

Genus TRIGONOSTOMA Blainville, 1827

Trigonostoma BLAINVILLE, 1827, Man. Malac. et Conchyl., p. 652.

Type by monotypy, *Delphinula trigonostoma* Lamarck, 1822 (= *Trigona pellucida* Perry, 1811). Recent, Indo-Pacific.

Subgenus VENTRILIA Jousseaume, 1887

Ventrilia JOUSSEAUME, 1887, Le Naturaliste, ser. 2, v. 1, fasc. 16, p. 194.

Type, by monotypy, *Ventrilia ventrilia* Jousseaume, 1887 (= *Cancellaria tenera* Philippi, 1848). Recent, tropical Western Atlantic.

TRIGONOSTOMA (VENTRILIA) BULLATUM (Sowerby, 1832)

Cancellaria bullata G. B. SOWERBY I, 1832, Zool. Soc. London, Proc., v. 17, p. 51; Conchological Illustrations, *Cancellaria,* p. 6, pl. 12, fig. 35.

Cancellaria dalli BARTSCH, 1915, U. S. Nat. Mus., Bull. 91, p. 33, pl. 4, fig. 2.

Cancellaria dalli was described by Bartsch from a single specimen purported to be from the Cape of Good Hope. Later workers have not found this species in South African waters. Examination of the type in the National Museum of Natural History (USNM type collection no. 17074) reveals that the type is a juvenile *Trigonostoma bullatum* (Sowerby, 1832), and was incorrectly attributed to the South African fauna.

Investigation of accession data reveals that this specimen is one of two originally accessioned as USNM no. 5107. The second specimen, an adult, is in the general collection correctly labelled as the tropical west American *Trigonostoma bullatum* (Sowerby), although when originally accessioned, as one lot, they were recorded only as *Cancellaria,* without a species name and without locality. Evidently the two specimens were separated and the juvenile labelled "C. G. Hope," after which Bartsch described it as a new species assuming that the locality on the label was correct. The small collection in which these specimens were received contained species from various parts of the world, but most were from the west coast of the Americas. Nothing is known of the donor, Commodore Aulick.

Cancellaria dalli Bartsch must therefore be placed in the synonomy of *Trigonostoma bullatum* (Sowerby), and the name removed from South African faunal lists.

The writer is deeply indebted to Dr. Harald A. Rehder. National Museum of Natural History, not only for confirming that *C. dalli* and *T. bullatum* are conspecific, but also for tracing the origin of the speimens in the Museum records.

TRIGONOSTOMA (VENTRILIA) SACELLUM n. sp.

Plate 2, fig. 4

Diagnosis: Nucleus smooth, naticoid, of about three whorls. First postnuclear whorl rounded, the following whorls rapidly forming a channeled suture. Postnuclear whorls, about five in number, rounded in the center of the whorl. Body whorl rounded with a high narrow shoulder behind dropping rapidly to an impressed suture, to form a deep, narrow channel. Small nodes formed by growth lines sometimes present on the shoulder at irregular intervals. Spiral sculpture consisting of slightly raised rounded cords, twelve or more on the body whorl, evenly interspaced with narrower spirals. No axial sculpture other than fine, irregularly spaced growth lines. Outer lip rounded, interior of lip evenly lirate. Columella inclined, with two descending folds. Basal keel rounded. Umbilicus deep, with evenly spaced spiral cords on the umbilical wall.

Dimensions of holotype: height 25.5 mm; diameter 18.3 mm.

Holotype: USNM 220092.

Type locality: TU 958, hillslope east of road from Boyd-Roosevelt highway to Refineria Panamá, about ½ km. north of junction at Cativa, Colon, Panamá. Gatun Formation, Pliocene.

Occurrence: Known only from the type locality.

Figured specimen: USNM 220092 (holotype).

Discussion: This species is unusual for the subgenus in that the shoulder of the shell is compressed, whereas in most species the upper part of the body whorl is relatively wide. It is also notable for its almost total lack of axial sculpture, having fine growth lines that form small nodes on the shoulder at irregular intervals, but it is otherwise devoid of axial sculpture. The species differs from most other New World congeners by this lack of axial sculpture.

Trigonostoma triumpha Olsson, 1964, of the Neogene of Ecuador also lacks axial sculpture, but that species has slight nodes on a central peripheral cord. Also, *T. triumpha* has a different overall shape, being

low-spired whereas *T. sacellum* is high-spired.

The only other *Trigonostoma* from this area without axial sculpture is *T. ecuadoriana* Pilsbry and Olsson, 1941, from the Pliocene of Ecuador. This species is distinguished by its evenly spaced strong spiral cords.

In general shape and sculpture *T. sacellum* resembles *T. tjibaliungense* (Martin, 1895) from the Pliocene of Java. *Trigonostoma tjibaliungense* differs in not being constricted at the shoulder and in having coarser spiral sculpture.

This new species is known only from two specimens collected by Drs. H. E. and E. H. Vokes. Both specimens have the outer lip broken. The type and the paratype, almost identical in size, have been deposited in the USNM.

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May 27, 1976

A NEW PINECREST CANCELLARIID (MOLLUSCA: GASTROPODA)

RICHARD E. PETIT*
NORTH MYRTLE BEACH, SOUTH CAROLINA
and
SHIRLEY E. HOERLE**
WEST PALM BEACH, FLORIDA

Genus TRIGONOSTOMA Blainville, 1827

Trigonostoma BLAINVILLE, 1827, Man. Malac. et Conchyl., p. 652.

Type, by monotypy, *Delphinula trigonostoma* Lamarck, 1822 (=*Trigona pellucida* Perry, 1811). Recent, Indo-Pacific.

Subgenus VENTRILIA Jousseaume, 1887

Ventrilia JOUSSEAUME, 1887, Le Naturaliste, ser. 2, v. 1, fasc. 16, p. 194. Type, by monotypy, *Ventrilia ventrilia* Jousseaume, 1887 (=*Cancellaria tenera* Philippi, 1848). Recent, tropical Western Atlantic.

TRIGONOSTOMA (VENTRILIA) SENARIUM n. sp.

Plate 2, fig. 5

Diagnosis: Shell heavy, broad, spire moderately high. Adult specimens consisting of one and one-half smooth nuclear whorls, four and one-half teleoconch whorls. Ornament initiated by numerous spiral threads crossing faint axial riblets; four distinct spiral cords developing on second post-nuclear whorl, increasing in strength with each turn; six broad, slightly rounded, coarsely noded spiral ribs on final whorl, shoulder cord being the largest, medially grooved and more heavily noded. Interspaces, narrow, flat, deep. Fine spiral threads cover the entire shell. Shoulder summits with adaxial slope, ornamented by fine spiral threads and oblique axial ribs. Aperture trigonal, the outer lip grooved, following the deep contours of the spiral cords. The resultant interior spirals in turn bearing strong lirations, extending well into the aperture. Columella with two descending folds that do not extend to the margin. Umbilicus deep, spirally striate, axially costate.

Dimensions: Holotype, height 34.1 mm; greatest diameter 26.3 mm.
Paratype 1, height 31.5 mm; greatest diameter 25.7 mm.
Paratype 2, height 32.9 mm; greatest diameter 26.2 mm.
Paratype 3, height 33.1 mm; greatest diameter 25.3 mm.
Paratype 4, height 27.6 mm; greatest diameter 23.4 mm.

Holotype: USNM 220085; paratypes USNM 220086-220089.

Type locality: TU locality 1000, borrow pit at east end of 17th Street, 3.2 miles east of Tuttle Road, about 8 miles east of U. S. Highway 301 in Sarasota, Sarasota County, Florida. Pinecrest Beds, Pliocene.

Occurrence: Known only from the type locality.

Figured Specimen: USNM 220085 (holotype).

Discussion: The characteristic broad, strap-like, noded spiral ribs distinguish this new species from all others of the genus occurring at the same locality (TU 1000). Other members of the genus such as *T. druidi* Olsson and Petit, *T. betsiae* Olsson and Petit, *T. tenerum* Philippi, and *T. perspectiva alumensis* Mansfield, appear at this locality and in other faunas of comparable age; however, as best as can be determined at this time, *T. senarium* is restricted to the borrow pits at Sarasota, Florida. Only *T. betsiae* bears a slight resemblance to the new species, but the primary spiral cords on *T. betsiae* do not attain the massive appearance and are not as coarsely noded as those of *T. senarium.* In profile the interspaces of *T. betsiae* are rounded, those of *T. senarium* are flat, thus making possible an immediate separation of the two species.

The only known *Trigonostoma* with similar sculpture is *T. ecuadoriana* Pilsbry and Olsson, 1941, from the Canoa Formation (Pliocene) of western Ecuador. This South American species has fourteen primary cords on the body whorl as contrasted to the six of *T. senarium,* and the early whorls of the two species are totally different.

The name *senarium,* a derivative of the Latin "senarius" meaning "of six", was selected to designate the six strong, broad spiral ribs, the main diagnostic characteristic of the species.

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*Research Associate, Paleontological Research Institution, Ithaca, New York.

**Research Associate, Paleontological Research Institution, Ithaca, New York; Associate, Department of Earth Sciences, Tulane University.

May 27, 1976

CENOZOIC MURICIDAE OF THE WESTERN ATLANTIC REGION

DERMOMUREX—ADDENDUM

EMILY H. VOKES
TULANE UNIVERSITY

During the summer of 1975 the writer had the occasion to visit St. Croix, U.S. Virgin Islands, where Mr. Gordon Nowell-Usticke makes his home. Examining the collections of this gentleman, it became painfully obvious that certain statements made in a recent publication (Vokes, 1975, p. 138 and 140) regarding the identity of a West Indian species of *Dermomurex* were in error. Therefore, this note is an attempt to correct this erroneous information as quickly as possible.

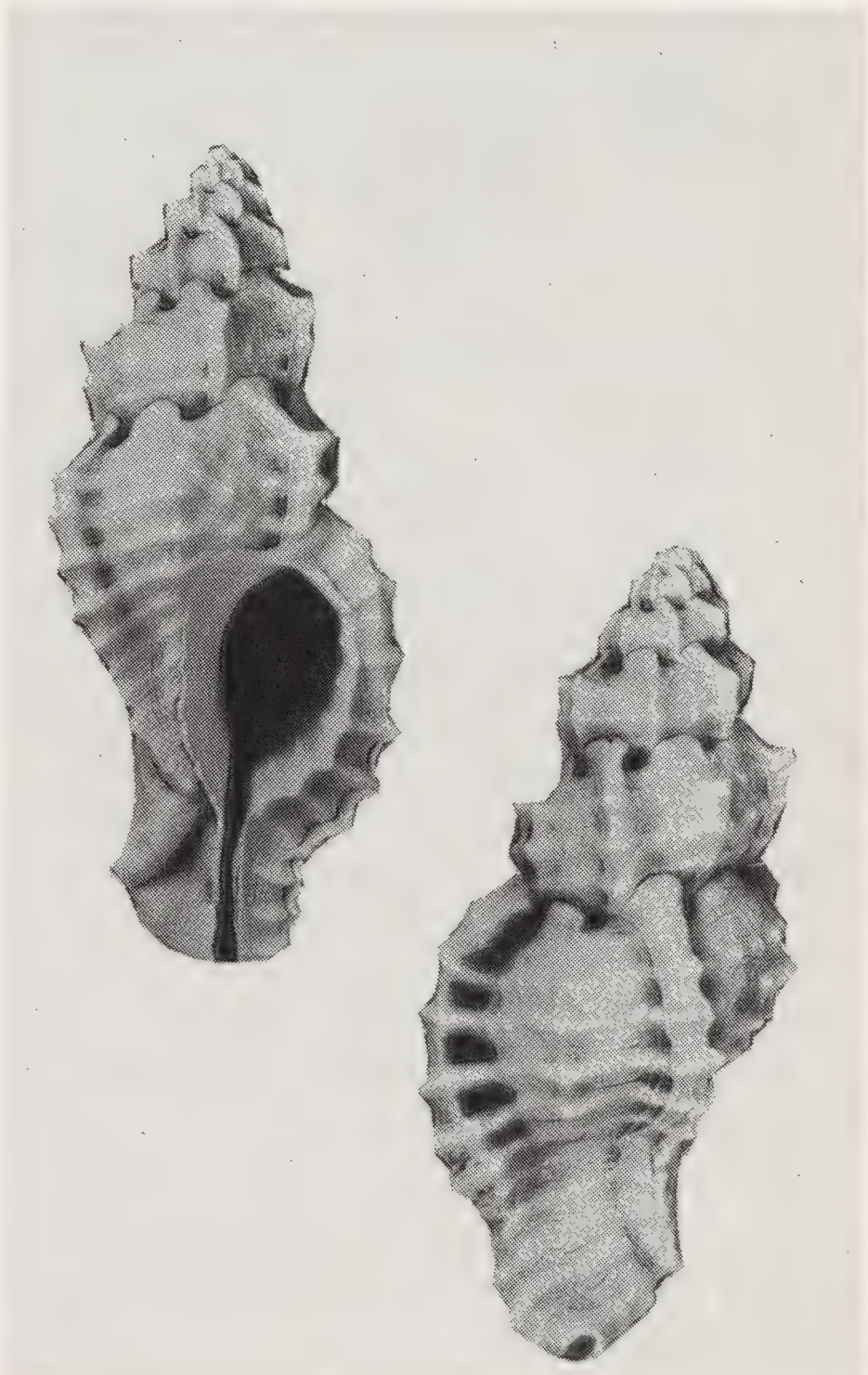
In 1969 Nowell-Usticke published a small booklet entitled "A supplementary list of new shells of St. Croix." In this paper he described a new species of *Dermomurex,* which he called *"Aspella pauperculum varians"* (1969, p. 15, pl. 3, no. 692). In the revised edition of the same pamphlet (1971, p. 12) he noted that: "The shell I named *Aspella varians* has, I find, a much earlier, overlooked name *Aspella cantrainei* Recluz." The present writer included *varians* in the synonymy of *Dermomurex pauperculus* (C. B. Adams), as *"Triton cantrainei"* is an unquestionable synonym of that species. However, seeing the specimens of *"Aspella varians"* in Nowell-Usticke's collections it was immediately apparent that these are not the same as *D. pauperculus* but are another West Indian species, which the writer had dismissed as being a case of mistaken locality, stating that the species was the same as *Dermomurex indentatus* (Carpenter) from West Mexico (Vokes, 1975, p. 138).

The species under discussion is that named by A. Adams (1864, p. 508) as *Murex alabastrum,* from Martinique. It was later figured by G. B. Sowerby in the *Thesaurus Conchyliorum* (1879, pl. 21, fig. 191) but has never been recognized since. Clench and Pérez Farfante (1945, p. 31) relegated it to synonymy as "a very young shell of *M. brevifrons* with very poorly developed spines." As noted, the present writer placed it in the synonymy of *Dermomurex indentatus* (Carpenter). In Nowell-Usticke's collections there are several examples of this species and it is obvious that it is not rare in the West Indies, and the original type locality was indeed correct.

DERMOMUREX (DERMOMUREX) ALABASTRUM (A. Adams)

Text figure 1

Murex alabastrum A. ADAMS, 1864, Zool. Soc. London, Proc. for 1863, p. 508.
Murex adamsii KOBELT, 1877, Jahr. Deutsch. Malac. Gesell., v. 4, p. 154 (unnecessary new name for *M. alabastrum* Adams, *non M. alabaster* Reeve).



Text figure 1. *Dermomurex (Dermomurex) alabastrum* (A. Adams). (X 2). Height 29.0 mm, diameter 13.0 mm; St. Croix, U.S. Virgin Islands. From the collection of G. W. Nowell-Usticke.

Murex alabastrum Adams. G. B. SOWERBY JR., 1879, Thesaurus Conchyliorum, v. 4, *Murex,* p. 20, pl. 21, fig. 191.

Murex adamsi Kobelt. TRYON, 1880, Man. Conch., v. 2, p. 86, pl. 40, fig. 514 (from Thes. Conch., fig. 191).

Murex alabastrum Adams. CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 31 (in synonymy of *M. brevifrons* Lamarck).

Aspella pauperculum varians NOWELL-USTICKE, 1969, A supplementary list of new shells of St. Croix, p. 15, pl. 3, fig. 692.

Aspella varians Nowell-Usticke. NOWELL-USTICKE, 1971, A supplementary listing of new shells (revised edition), p. 12, pl. 6 (no number). (In synonymy with *Aspella cantrainei* Recluz).

[Dermomurex] alabastrum (Adams). E. H. VOKES, 1971, Bulls. Amer. Paleontology, v. 61, no. 268, p. 14.

Dermomurex alabastrum (Adams). E. H. VOKES, 1975, Tulane Stud. Geol. Paleont., v. 11, no. 3, p. 138.

Diagnosis: "M. testa ovato-fusiformi, alba; spira elata, quam apertura longiore; anfractibus convexis, varicibus validis rotundatis squamosis, squamulis incrassatis imbricatis postice productis et spiniformibus instructis, interspatiis nodoso-plicatis, squama lobiformi erecta ad suturas ornatis, transversim in toto striatis et lirulis transversis ad plicas nodulosis instructis: apertura parva, ovata; labio lavi, arcuato, canali mediocri angusto recurvato; labro extus late varicoso." (A. Adams, 1864).

Dimensions of holotype: "long. 14 lines [29.5 mm], lat. 3 lines [6.3 mm—obviously an error for 6 lines = 12.7 mm]." (Adams, 1864).

Holotype: Lost, *fide* K. Thomas, *in litt.,* British Museum (Nat. Hist.).

Type locality: Martinique, French West Indies.

Figured specimen: Paratype *"Aspella varians"* Nowell-Usticke; height 29.0 mm, diameter 13.0 mm; locality St. Croix, U.S. Virgin Islands, Recent.

Discussion: This long-lost species is, as was noted in the previous discussion by the writer (Vokes, 1975, p. 138), clearly the descendant of *Dermomurex engonatus* (Dall) from the Pliocene and Pleistocene of Florida. The principal difference between the two forms is that *D. alabastrum* attains a larger size on the average than does *D. engonatus* and loses its intermediate varices at an earlier stage. This is somewhat variable and it is probable that the two forms are, in fact, conspecific. In view of the long acceptance of the name *D. engonatus* for the common Florida fossil it seems better to keep both names, but with the realization that the two may well represent the same biologic species, or local varients at best.

Another specimen was provided through the kindness of Mr. J. Gibson-Smith, of Caracas, Venezuela, who noted that it came from a lot of ten specimens from a coralline dredged spoilbank at Borburata, near Puerto Cabello, Edo. Carabobo, Venezuela. Obviously this species is widespread throughout the Caribbean and why it is not represented in collections cannot be answered.

The writer is most grateful to Mr. Nowell-Usticke for the loan of the figured specimen, as well as for the opportunity to examine his collections. She also thanks Mr. Gibson-Smith for the additional range data.

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May 27, 1976

A NEW SUBGENUS AND SPECIES OF *PETRICOLA* (MOLLUSCA: BIVALVIA) FROM THE PLIOCENE OF SOUTHERN FLORIDA

HAROLD E. VOKES
TULANE UNIVERSITY

Mrs. R. C. Hoerle of West Palm Beach, Florida, recently sent an unusual bivalved mollusk requesting information as to its possible systematic position. It was collected from a coral-rich faunal association that had been dredged from a drainage canal southwest of Immokalee in northern Collier County, Florida. The associated fauna in the spoil bank is thought to be predominantly of Caloosahatchee (upper Pliocene) age although a few forms suggest an upper Pinecrest (middle Pliocene) assignment.

The hinge and pallial line of the species clearly reveal its relationship with the genus *Petricola* Lamarck, 1801, but the ornamentation is wholly different from that to be observed in that genus and, in a general way, is somewhat reminiscent of that observed in some unionid forms. Accordingly, the species is here described as representative of a new subgenus of *Petricola.*

Family PETRICOLIDAE Deshayes, 1839
Genus PETRICOLA Lamarck, 1801

Type species, by subsequent designation, Schmidt, 1818: *Petricola costata* Lamarck = *Venus lapicida* Gmelin. Pliocene to Recent, South Carolina to Texas, the Antilles and Caribbean region.

Petricola s.s. includes nestling species, often found in holes in coral heads, with an external ornament of fine, radial to zigzag riblets. Most specimens in the Tulane University collections are less than 25 mm in length.

Subgenus PETRICOXENICA
H. E. Vokes, new subgenus

Type species: *Petricolaria (Petricoxenica) concoralla* n. sp. Pliocene; Caloosahatchee Formation (?), Florida.

Etymology: Combination of *Petricola* and *xenikos* (Gr.), strange; gender-feminine.

Diagnosis: Shell larger than most species of *Petricola* s.s., elongate-ovate in profile, moderately inflated. Ornament strongly nodose upon a pustulate shell-surface. Hinge similar to that of *Petricola* s.s., having two cardinals in the right valve and three in the left with the median left cardinal bifid. Pallial line with a wide pallial sinus whose rounded anterior end is situated approximately at the anterior third of the total length of the valve and whose ventral side is co-extensive with the pallial line over the posterior third of its length.

The feature that serves to distinguish *Petricoxenica* from *Petricola* s.s. and its other subgenera is the unusual nodose ornamentation associated with the pustulate shell surface.

PETRICOLA (PETRICOXENICA) CONCORALLA H. E. Vokes, n. sp.

Text figure 1

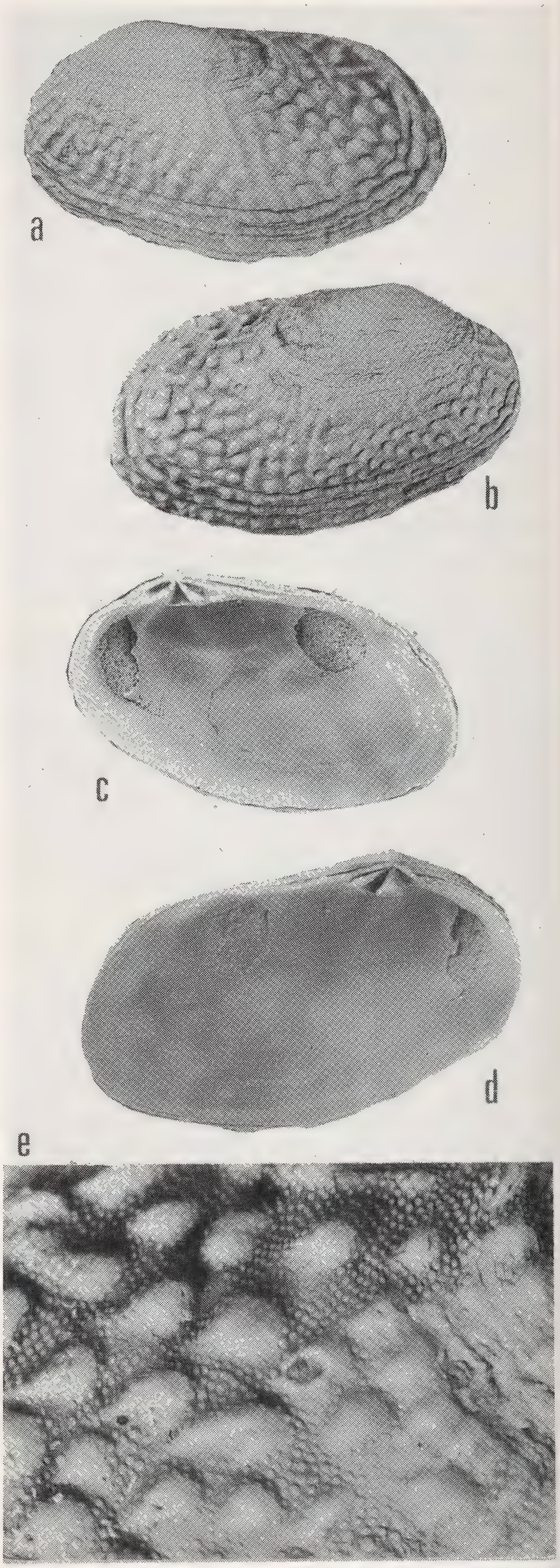
Diagnosis: Shell elongate-ovate in profile, moderately inflated; umbones low, not prominent, situated in advance of the anterior fourth of the length of the valve; anterior margin rounded, ventral broadly and regularly arched rounding rather sharply postero-ventrally to the gently convex posterior end, which in turn gently curves into the relatively straight dorsal margin. Ornament distinctive, the low umbones being essentially smooth (possibly slightly worn) but with a rather strong pustulation soon developing, initially upon the postero-dorsal area, but rapidly coming to overlie all parts of the valve surface. Ventral and lateral to the first initiation of the pustules the valves develop a strongly nodose ornament that on the anterior and medial areas is crudely aligned in a manner suggestive of interrupted and irregular radial ribbing. On the specimen at hand this ribbing is more pronounced and least interrupted at about the midlength of the left valve. The postero-umbonal ridge and the surface dorsal to it are marked by strong, rounded to slightly drawn out and almost comma-shaped nodes whose arrangement suggests a possible origin on crudely divaricate ribbing. Towards the margins of the valves there are growth interruptions over which the coarsely nodose ornament persists but with the surficial pustulation absent on all but the posterior

end. Lunule absent, but a flattened, exceedingly narrow smooth area posterior to the narrow ligamental groove suggestive of an escutcheon is to be noted, more prominently developed upon the left valve than on the right.

Hinge typically petricolid: two cardinals in the right valve and three in the left with the anterior left cardinal immediately adjacent to and fused with the valve margin, the median cardinal bifid, strong, subtriangular, and the posterior one laminar; no lateral teeth in either valve. Anterior adductor scar slightly elongate, posterior one is almost round. Pallial line impressed, with a large pallial sinus that is almost one-half as wide as long with its rounded anterior end reaching almost to the anterior third of the total length. Inner valve margins smooth.

Holotype: USNM 647650, length 32.6 mm, height 18.3 mm, diameter (paired valves) 13.2 mm. Locality TU 1175; spoil bank on south side of canal 0.6 mile south of State Highway 858 at a point 2.0 miles east of the junction of Highway 858 with State Highway 846, Collier County, Florida.

Remarks: The paired valves of the holotype specimen show a sharp posterior deflection toward the right. Mrs. Hoerle *(in litt.)* states that individual valves in her collection show no trace of such a feature, hence it is here interpreted as one evidence of a nestling habit for the species and as representing an individual reaction to conditions in its own immediate nestling situation rather than being a specific or subgeneric characteristic.



Text figure 1. *Petricola (Petricoxenica) concoralla* H. E. Vokes, n. sp. Holotype, USNM 647650. (a & d) right valve; (b & c) left valve. X 1½ approx. (e) portion of surface, enlarged.

May 27, 1976

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OSTRACODA FROM THE LOUISIANA CONTINENTAL SHELF

MERVIN KONTROVITZ
RIDER COLLEGE, TRENTON, NEW JERSEY

CONTENTS

I. ABSTRACT 49
II. INTRODUCTION 50
III. ACKNOWLEDGMENTS 50
IV. STUDY AREA 50
V. OSTRACODE ASSEMBLAGES 54
VI. SUMMARY AND CONCLUSIONS 56
VII. SYSTEMATIC DESCRIPTIONS 58
VIII. STATION LOCATIONS 94
IX. LITERATURE CITED 96

ILLUSTRATIONS

TEXT FIGURE 1 51
TEXT FIGURE 2 53
TEXT FIGURE 3 55
TEXT FIGURE 4 57
TEXT FIGURE 5 88
TABLE 1 . . . . . opposite page 58
PLATE 1 67
PLATE 2 71
PLATE 3 75
PLATE 4 79
PLATE 5 83
PLATE 6 87
PLATE 7 91
PLATE 8 97

I. ABSTRACT

There have been no published comprehensive studies of the Ostracoda of the Louisiana Continental Shelf west of the Mississippi River Delta. This paper presents a study of that area and includes taxonomic and environmental data. Ostracode specimens were taken from 123 bottom samples of Holocene age, collected on the continental shelf and slope.

Five distinct ostracode assemblages are recognized and related to water depth and sediment grain size. Several individual species are also recognized as useful indicators of water depth. Water depth and salinity ranges of several species are extended in relation to previous reports.

Sixty species are identified, with nine species and two subspecies considered new. The following new taxa are described: *Actinocythereis vandenboldi, Basslerites vokesi, Cytherella vermilionensis, Cytheropteron morgani, Cytheropteron tumulosimilis, Loxoconcha moralesi, Luvula gigartonoides,*

EDITORIAL COMMITTEE FOR THIS PAPER:
DORIS M. CURTIS, Shell Oil Company, Houston, Texas
JOSEPH E. HAZEL, U. S. National Museum, Washington, D.C.
W.A. VAN DEN BOLD, Louisiana State University, Baton Rouge, Louisiana

Macrocyprina skinneri, Puriana krutaki, Protocytheretta montezuma louisianensis, and *Munseyella bermudezi louisianensis.*

II. INTRODUCTION

There have been no comprehensive studies of the Ostracoda of the Louisiana Continental Shelf that include taxonomic and ecological treatment. This project was undertaken to present such a study for the region from the Mississippi River Delta and the Louisiana Continental Shelf. Many papers have been published on the ostracodes of other regions of the Gulf of Mexico as indicated in the bibliography of this study.

The current study considers the taxonomy of all ostracodes recovered from bottom samples; the systematic descriptions include several new species and subspecies, in addition to revision of the classification of certain previously described forms.

The concept of facies faunas is clearly demonstrated by the several distinct assemblages of ostracodes. It will be shown that even in apparently similar habitats, such as a narrow depth range, there are distinct and sometimes mutually exclusive assemblages.

The distribution of valves and carapaces (adult and juvenile) is no less important than the study of living specimens. Regardless of post-mortem transportation, a specimen can be useful as an environmental indicator if the usual site of deposition is known.

The specimens used were taken from 123 samples; 100 were bottom grab samples provided by a major oil company as washed material. Twenty-three samples were taken from the top few centimeters of cores collected on the Louisiana State University-United States Geological Survey Cruise II, Dr. James P. Morgan, Scientist in Charge.

III. ACKNOWLEDGMENTS

The writer expresses his gratitude to Dr. Hubert C. Skinner, Tulane University, who suggested this study and secured all samples used. Dr. Skinner's constant encouragement allowed the completion of the study. Dr. Harold E. Vokes and Dr. Emily H. Vokes, Tulane University, offered much useful advice and criticism that was incorporated into this report.

Twenty-three bottom samples were provided by Dr. James P. Morgan, Director of Louisiana State University-United States Geological Survey Cruise II. These materials make up a substantial part of the total samples utilized.

Special appreciation is expressed to Dr. W. A. van den Bold, Louisiana State University (Baton Rouge), for his detailed evaluation of the manuscript. His pertinent suggestions and criticisms especially in regard to taxonomy, were extremely useful in improving this study.

Dr. R. E. Nadeau, Department of Communications, Purdue University, assisted by offering advice regarding the proper usage of the new species and subspecies names.

The members of the Editorial Committee are thanked for their useful comments in review of this study.

IV. THE STUDY AREA

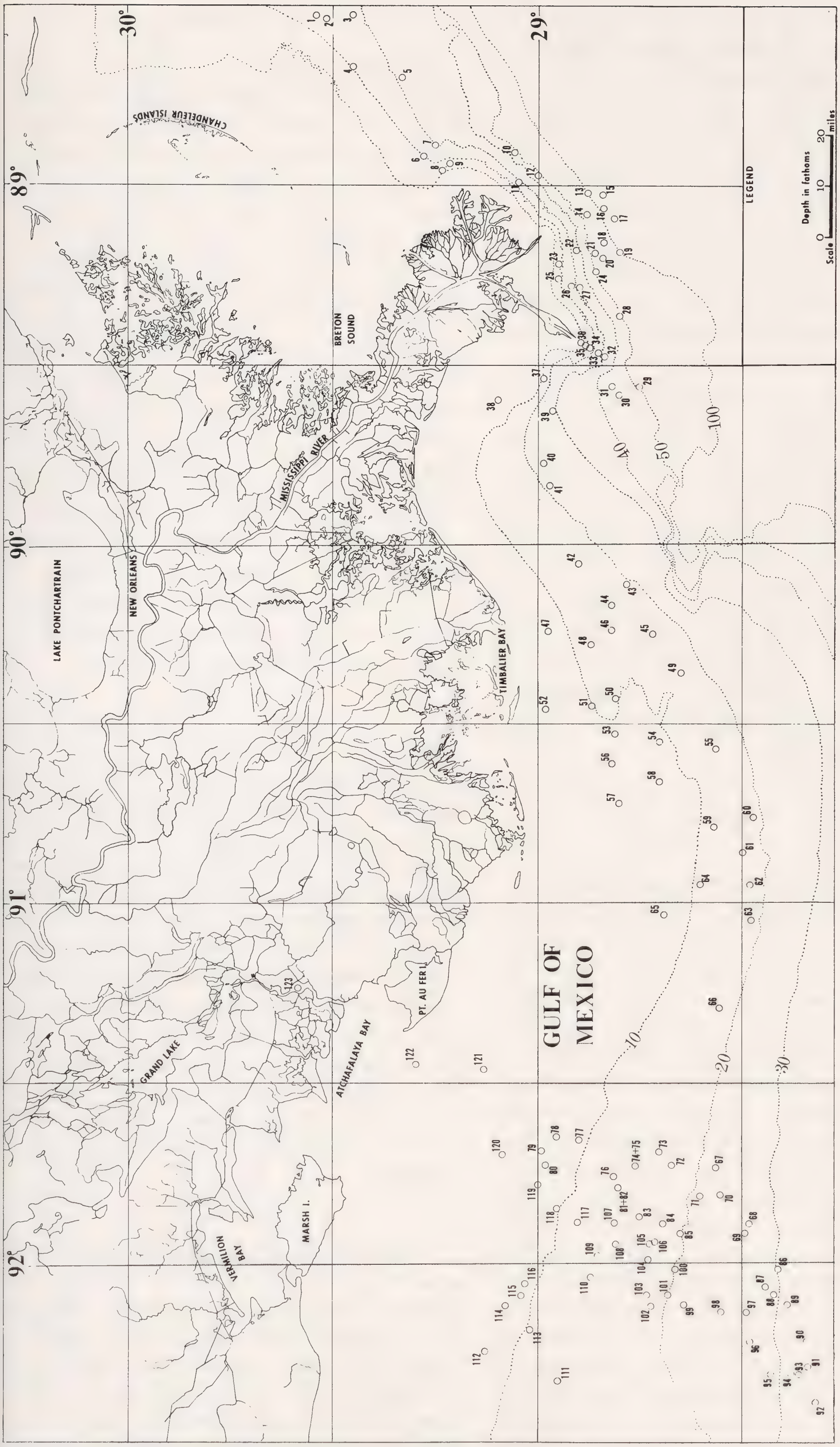
A. Introduction

The samples used in this study were collected from the Louisiana continental shelf and slope between 88° 30' and 92° 30' W. The northern limit of the sampled area is the coast of central Louisiana and about 29° 30' N to the east of the Mississippi River Delta. Samples were obtained as far south as 28° 18' N in the area off the central Louisiana coast (see Text Figure 1 and Appendix 1).

The shelf, west of the delta, is less than 50 miles wide at 90° W, but widens to more than 125 miles off western Louisiana and eastern Texas. The modern delta extends across the shelf nearly to the edge of the continental slope (Gealy, 1955; Murray, 1961).

B. Sea Temperature

The average July and February sea surface temperatures are approximately 84°F and 66-68°F, respectively, as indicated on Text Figure 2. Thompson (1951) measured water temperatures at offshore oil platforms located in 11 feet of water about 4.9 miles west-southwest of Point Au Fer Island. Temperatures from August to November, at



Text figure 1. Study area and collection locations.

the gulf bottom, were about the same as those at the sea surface. From January to May, the bottom temperatures were 3-4°F higher than those at the surface. Thompson explained this phenomenon as the result of a warm but more dense water mass, at the bottom in that region. Scruton (1956) recorded large temperature variation over short periods at 36 to 48 foot depths, north of the delta. He indicated that similar variations take place offshore at comparable depths. Mississippi River water temperatures exert the major control on gulf waters near the delta and to a maximum depth of two or three feet (Scruton, 1956; Akers, 1952).

Seasonal temperature changes affect the upper 250 to 550 feet of the water column; the upper 90 feet are most affected with even short term local variations reflected at this depth. Stations 6,7,8,9 and 29 of this study are in areas with winter temperatures of about 68°F at 100 feet and 63°F at 300 feet. Summer readings are about 81°F at 100 feet (Phleger, 1951; Henry, 1961). Most of the samples in this study were taken from depths that are affected by annual temperature variations.

C. Salinity

Surface salinity in the open Gulf ranges from 36.25 to 36.36‰. From the surface to a depth of about 330 feet, there is a slight increase in salinity with depth. Below 330 feet, salinities decrease to about 34.9‰ at 2000 feet. Nearshore localities, especially those near the Mississippi Delta, show reduced salinities caused by direct runoff and stream discharge. Salinity changes involve the water column to a depth of 50 feet over long duration, with the greatest period of variability during the spring months (Phleger, 1951; Leipper, 1954; Henry, 1961). Data supplied by Dr. Ray E. Ferrel of Louisiana State University indicate that the following stations are less than fully marine during at least part of the year: Stations 52, 121, 122, and 123. All other stations not mentioned are fully marine; those near the delta are at such depth as to be below the zone of salinity reduction.

D. Turbidity

The Mississippi River and other nearby streams contribute much suspended matter to the Gulf of Mexico. Nearshore, the turbid layers have a vertical dimension of up to five feet, but they quickly thin in a direction along a main current. Outside a main current, the amount is reduced to about one-twentieth of that recorded at the mouth of a river pass (Scruton and Moore, 1953). Bates (1953) and Shoemaker (1954) recorded Secchi disc extinction depths for the area near several stations used in the current study. From those data, it is probable that only Stations 47, 52, 121, 122, and 123 are directly affected by highly turbid water. Other stations are deeper, in areas too far offshore to be engulfed in undiluted turbid waters. It should be stressed that probably all stations are subject to deposition of material from suspension from the water above, but the concentration is greatly reduced from that near a river mouth.

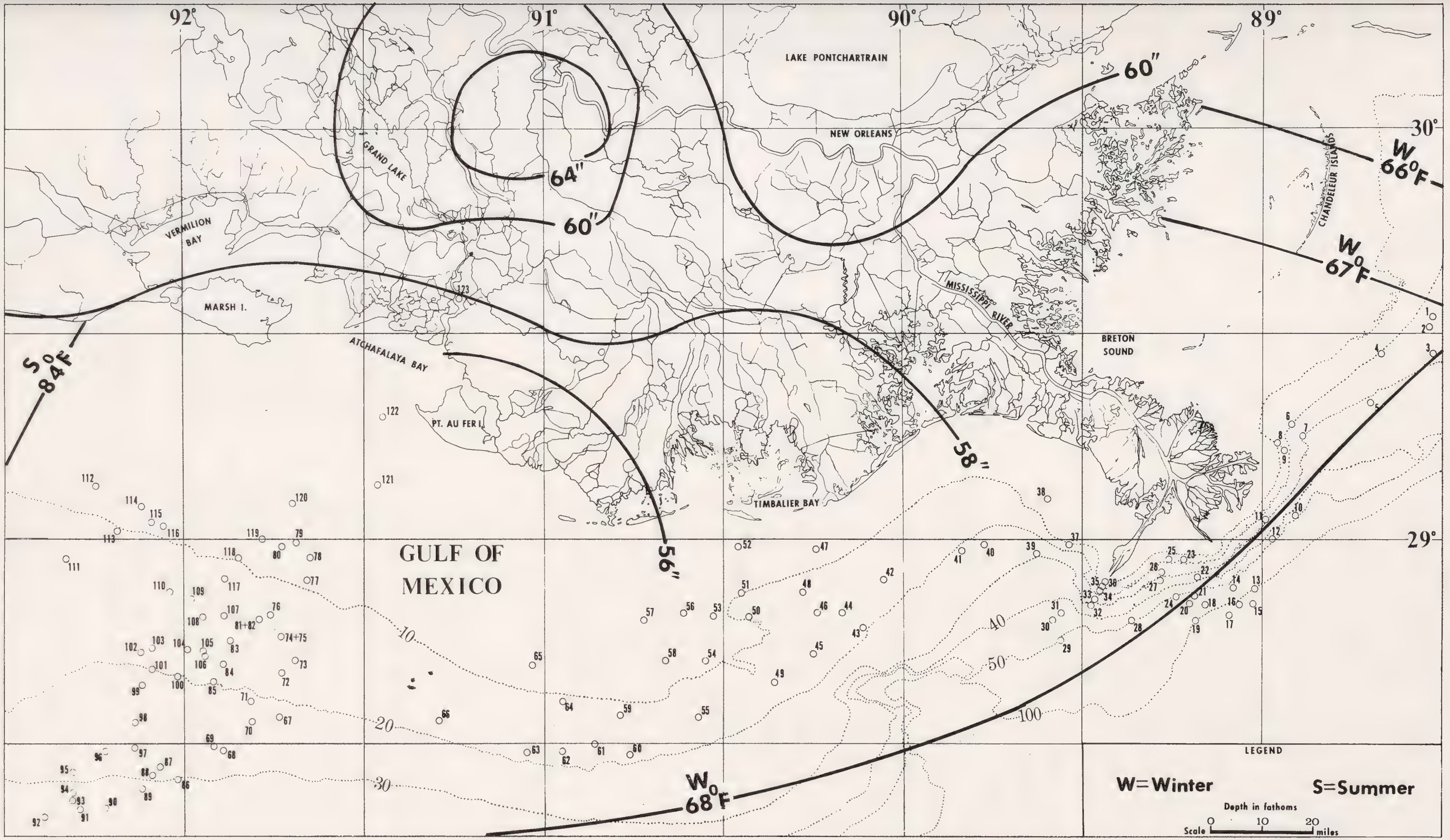
E. Tides and Waves

The tidal range in the area is low, averaging less than two feet throughout the Louisiana coastal area. Because of the low tidal range, meteorological effects are important, with storm tides, notably from hurricanes, reaching heights over 10 feet (Marmer, 1954; Thompson, 1955; Curray, 1960).

Deep water waves in the Gulf rarely exceed three feet; these can and do move sand when they reach shoal areas. Curray (1960) has stated, however, that even during hurricanes there is little or no net transport from wave action although there is some vertical displacement including microorganisms.

F. Currents

Semi-permanent surface currents in this area are generated by north or northwest flowing waters that pass between Cuba and the Yucatán Peninsula. In the summer, waters split into two currents south of the Mississippi River Delta at about 26° 30'N. West of the delta, the resultant current direction is from the south or southeast. Immedi-



Text figure 2. Average sea surface temperatures and average precipitation (after Dyke, 1941; Leipper, 1954).

ately to the south and southeast of the delta, the main currents flow from the south and southwest. Winter currents, west of the delta, are from a more easterly direction than the summer currents (see Text Fig. 3) (Leipper, 1954; Curray, 1961; Henry, 1961).

G. Sediments

The general distribution of sediments off the central Louisiana coast is such that there are sandy materials near the shore and finer sediment offshore. Silty clays and clayey silt zones occur on the outer and middle continental shelf (Curray, 1960). The sediments are facies deposited in deltaic and marginal deltaic shelf environments (Fisk and McClelland, 1959).

The specific grain sizes associated with each of the stations of this report are given in Appendix I and are summarized for the location of each of the species in the text of this study. The sediment size classification is after Shepard (1954) and other data are after Thompson (1955) and Curray (1960).

Phleger (1960) sampled the area off the Louisiana coast; based on Foraminifera faunas, he indicated the thickness of the Holocene sediments on the shelf and slope as being no less than about 40 inches. Because all material examined in this study was obtained with a bottom grab sampler or from the top few centimeters of cores, it is clear that all samples are from the top of the Holocene sequence.

V. OSTRACODE ASSEMBLAGES

Several assemblages of ostracodes are recognized; each is a group of species represented by remains that usually occur together. Each station is not necessarily included in one of the assemblages because a particular station may not have a group of ostracodes that is seen repeatedly at other stations. That is, particular stations with ostracodes present may have rather unique associations of species while others have an association represented at many localities. The latter are those herein referred to as assemblages.

The assemblages are restricted to the water depths indicated and in most cases each is restricted to a limited range of sediment textures. At least 95% of the total specimens of the species listed below occur at the depth intervals indicated. The species listed may be part of one or more assemblages. Even in cases where only a few specimens were recovered from a sample, most of the species in the assemblage were present. The distribution of each assemblage is shown in Text Figure 4.

The following symbols were used to indicate the typical abundance of a species in an association.

R(Rare)	1-4 valves
C (Common)	5-10
A(Abundant)	11-25
VA(Very abundant)	26-50
F(Flood)	over 50

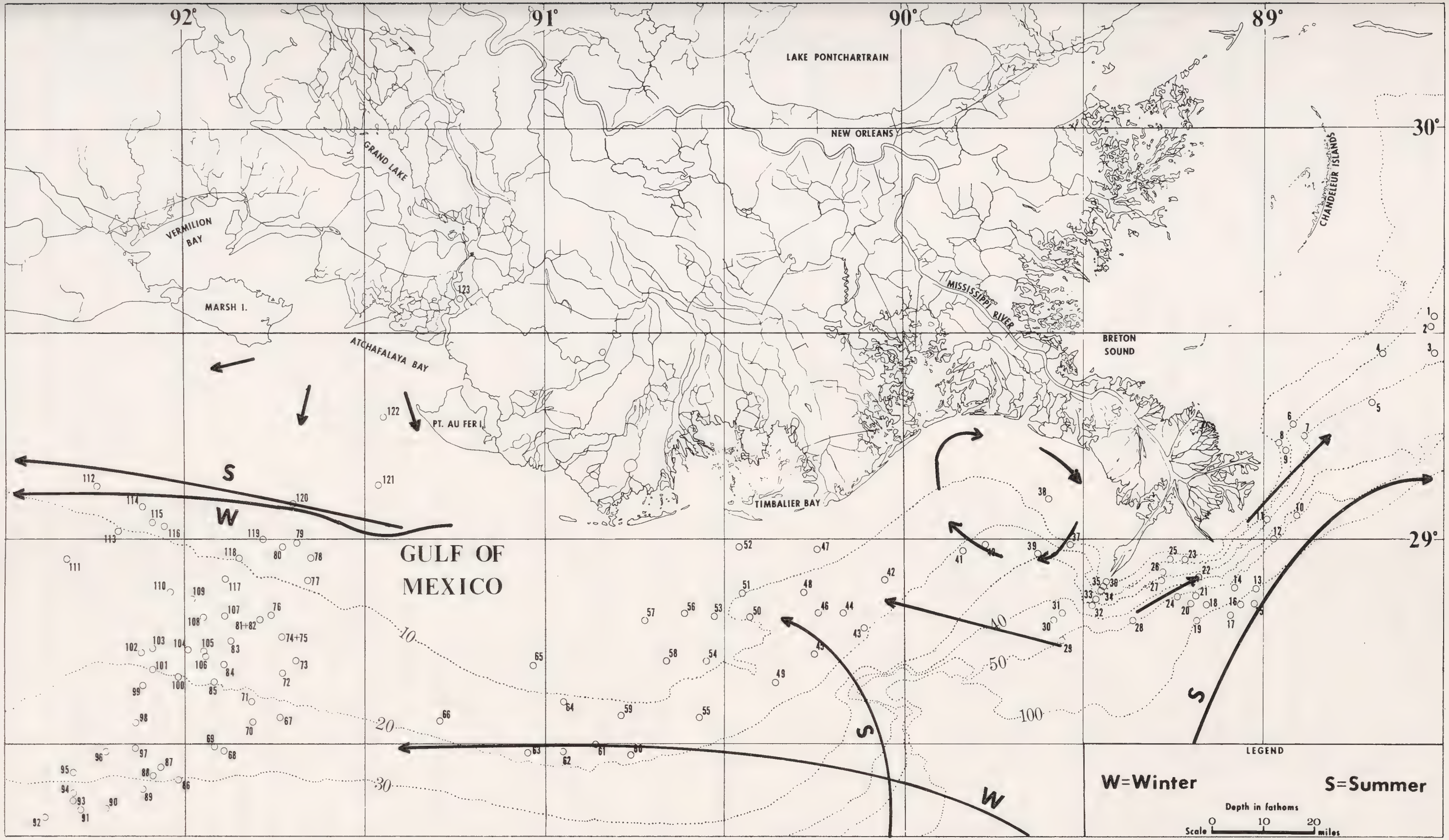
Bouma *et al.* (1971) presented convincing arguments that "a quasi-permanent upwelling zone" exists in an area south of the Mississippi River Delta. Although it is stated that sediments are displaced by upwelling, it is clear that the unique circumstances of geomorphology and prevailing winds responsible must be local and include only a small portion of the area of the present study. Assemblage #3 is the only one involved, with Station 28 and possibly Station 32 included. Other studies (Huang and Goodell, 1970, Walker and Massingill, 1970) indicate that much slumping has taken place in the regions south and southeast of the present delta. Those reports deal with areas beyond the present study area and the described disturbance of the sediment does not include the areal extent of the assemblages described herein.

Assemblage #1; 50-200 feet; clayey silts and silty clays; foraminifera planktonic benthonic ratio (P/B) of .01 to .15.

Echinocythereis margaritifera	R-A
Hulingsina ashermani	R-VA
Protocytheretta karlana	R-VA
Pterygocythereis miocenica	R-VA
Puriana krutaki n. sp.	R-C
Cytherella vermilionensis n. sp.	R-C
Loxoconcha moralesi n. sp.	R-VA

Assemblage #2; 50-200 feet; clayey silts, P/B ratios of .01 to .15.

Actinocythereis gomillionensis	R-C
Protocytheretta montezuma louisianensis n. subsp.	R-VA
Pterygocythereis miocenica	R-C



Text figure 3. Semipermanent surface currents (after Leipper, 1954; Thompson, 1951).

Assemblage #3; 50-300 feet; clayey silt and sand-silt-clay mixtures; P/B ratios of .01 to .26.

Basslerites vokesi n. sp.	R-C
Cytheropteron hamatum	R-C
Loxoconcha cf. *L. matagordensis*	R-A

Assemblage #4; 150-200 feet; silty clays and clayey silts; P/B ratios of .13-.35.

Cytheropteron morgani n. sp.	R-C
Henryhowella ex. gp. *asperrima*	R-VA
Protocytheretta karlana	R-C
Pterygocythereis miocenica	C
Actinocythereis vandenboldi n. sp.	R-VA
Pterygocythereis americana	R

In addition to the characteristic assemblages recognized, certain species do not occur in associations, but do have limited depth range distribution; these are listed below.

Aurila floridana	100-150 feet	R-C
Pellucistoma magniventra	100-150 feet	R-C
Argilloecia posterotruncata	300-800 feet	R
Munseyella bermudezi louisianensis	300-350 feet	R-C
Neonesidea sp.	350-425 feet	R
Krithe cf. *K. producta*	100-800 feet	R-A

VI. SUMMARY AND CONCLUSIONS

One-hundred and four of the 123 bottom samples examined contained ostracode valves and/or carapaces. Samples away from the delta front, each contained up to several hundred valves and often over twenty species. Nineteen of the 123 samples contained no ostracode remains; 18 of the barren samples were located close to the delta front. The absence of specimens is not because the high rates of sedimentation result in dilution, thus yielding sparse ostrocodal content; some of the same samples contained over 800 benthonic foraminifers. No explanations can be offered at this time for the absence of ostracodes in these particular samples.

The total fauna is diverse, but does yield evidence of distinct assemblages that are useful in paleoecological interpretation.

Stations 52, 121, and 122, located in the open gulf, undergo salinity reduction for at least part of the year. The ostracodes in these samples are known to tolerate salinities below 35‰. *Protocytheretta* found at several of these stations, has been reported previously only from marine waters. It is associated with the fresh-brackish water genera *Candona* and *Cyprideis.*

Several taxa occur in this study area at depths greater than previously reported. The wide depth range of the samples studied has allowed the writer to extend known limits of the depositional environments for the remains of eight species. These are listed below with the depth of occurrence in this study.

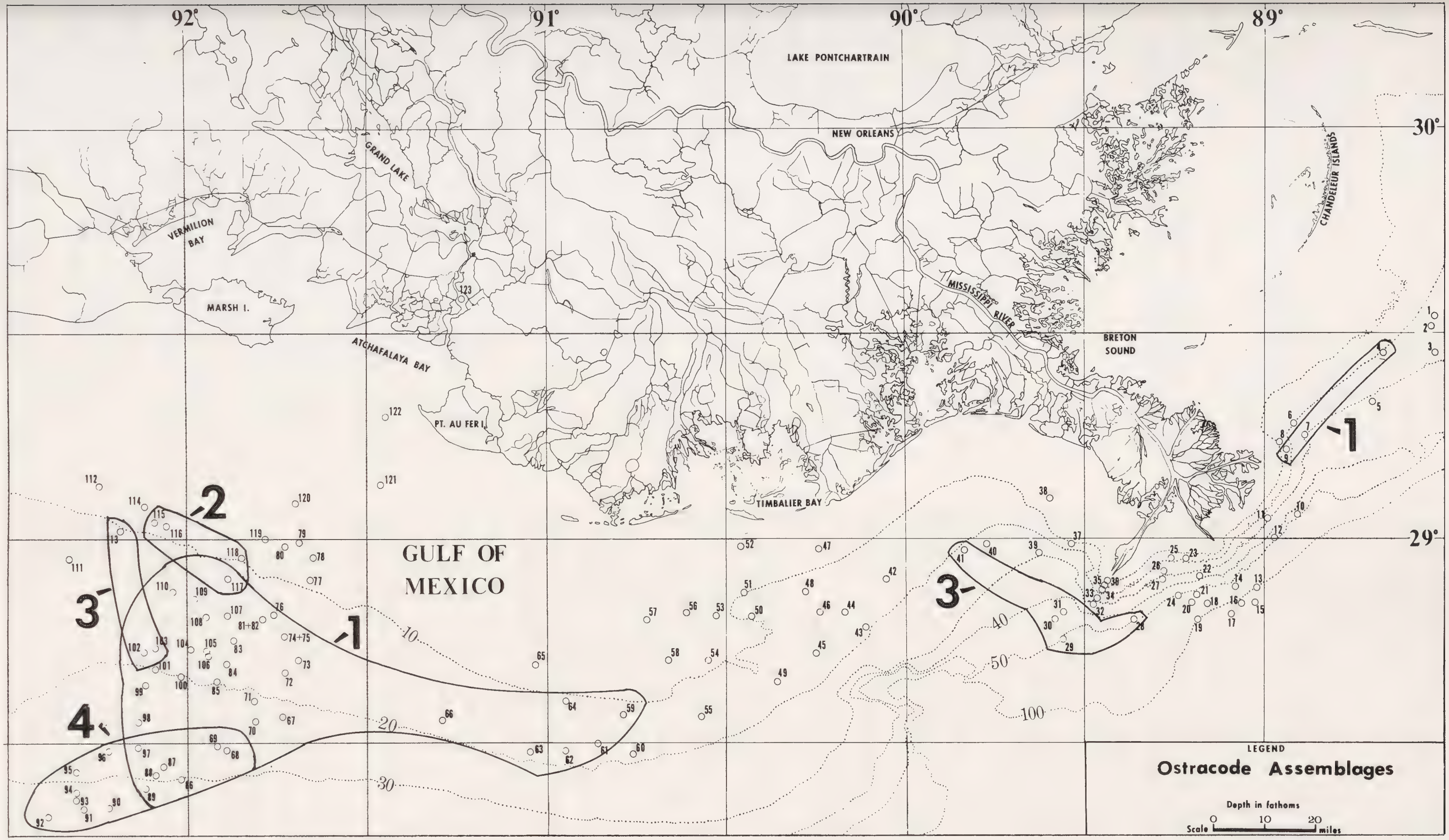
Candona aff. *C. patzcuaro* Tressler	50 feet
Haplocytheridea cf. *H. bradyi* (Stephenson)	204 feet
Perissocythereidea excavata Swain	54-102 feet
Perissocytheridea rugata Swain	54-88 feet
Pumilocytheridea cf. *P. sandbergi* van den Bold	54-192 feet
Aurila floridana Benson and Coleman	99-204 feet
Actinocythereis gomillionensis (Howe and Ellis)	54-192 feet
Echinocythereis margaritifera (Brady)	42-788 feet

Certain deep water forms are not abundant in occurrence, but are reliable depth indicators when present. These include *Krithe* cf. *K. producta* Brady, *Argilloecia posterotruncata* van den Bold and *Neonsidea* sp. The species *Krithe* cf. *K. producta* and *Macrocyprina skinneri* n. sp. show a systematic increase in absolute abundance with increasing water depth.

Several taxa are characteristically found in limited types of sediment. This factor is interpreted as important in controlling their distribution. The forms are:

Munseyella bermudezi louisianensis n. subsp.	silty clay
Echinocythereis margaritifera (Brady)	clayey silt or silty clay
Henryhowella ex. gr. *asperrima* (Reuss)	silty clay

Particular assemblages are accurate depth indicators. There may be several discrete assemblages at different localities within any depth interval, thus, more than one faunule is recognized as indicative of the interval and the usefulness of ostracodal faunas and their reliability as ecologic indicators is enhanced.



Text figure 4. Distribution of ostracode assemblages 1, 2, 3, and 4.

Assemblage	Water depth (feet)
#1	50-200
#2	50-200
#3	50-300
#4	150-200

Some species do not occur in association with any other species in a discernable manner; however, they are still useful, in that they are generally confined to a definite depth interval. These include deeper water species of *Argilloecia, Basslerites, Krithe, Munseyella,* and *Neonesidea.*

Ostracodes reported in this study consist of dead remains, but such material does provide useful assemblages for environmental reconstruction, as the final resting place of Recent (Holocene) carapaces provides the best evidence for comparison with faunal associations in the rock record. Although no single factor in the ecology can be isolated as the principal control of distribution, water depth is a useful and convenient expression of that distribution.

VII. SYSTEMATIC DESCRIPTIONS

A section on ecology is included with each species relating the environmental conditions in this study to previous reports from Holocene sediments. The total valve count is given on a general distribution chart. Unless noted, each species occurred in normal marine salinities; sediment classification is after Shepard (1954). Foraminiferal planktonic/benthonic ratios (P/B) are given so that group can be compared to the occurrence of ostracodes. Specimens are deposited in the H. V. Howe Collection (HVH) at Louisiana State University, Baton Rouge, Louisiana.

Subclass OSTRADOCA Latreille, 1806
Order PODOCOPIDA Müller, 1894
Subclass PODOCOPINA Sars, 1866
Superfamily BAIRDIACEA Sars, 1866
Family BAIRDIIDAE Sars, 1866
Subfamily BAIRDIINAE, Sars, 1888
Genus NEONESIDEA Maddocks, 1969

NEONESIDEA sp.
Plate 1, figure 1

DIMENSIONS: ?Juvenile, left valve, length .59 mm; height .39 mm.

REMARKS: The three poorly preserved juvenile specimens are inadequate for specific identification.

OCCURRENCE: Stations 7, 9, and 20.

ECOLOGY: Water depths of 192 to 480 feet; sand-silt-clay and silty clay; foraminiferal planktonic/benthonic ratios (P/B) of .005 to .02.

Family MACROCYPRIDIDAE Müller, 1912
Genus MACROCYPRINA Triebel, 1960

MACROCYPRINA SKINNERI
Kontrovitz, n. sp.
Plate 1, figure 2, 3

DIAGNOSIS: Distinguished by its highly arched dorsum, composed of four straight line segments in lateral view, broadly rounded posterior, narrowly rounded anterior, and pronounced overlap of the right valve in front of hinge. Left valve highest at mid-length.

DESCRIPTION: Moderately calcified, small for the genus. Lateral view, highly arched dorsum of four straight line segments, (1) from anterior margin to anterior cardinal angle, (2) anterior cardinal angle to greatest height, (3) greatest height to posterior cardinal angle, (4) posterior cardinal angle to posterior margin. Ventral margin, concave and with slight sinuosity. Anterior narrowly rounded; posterior broadly rounded. Greatest height at mid-length. Surface is smooth.

Dorsal view: Carapace tapers evenly to anterior and posterior, pronounced overlap of right valve in front of hinge, left valve higher at mid-length.

Internal view: Hinge, right valve, anterior, elongate crenulate socket, followed by low crenulate tooth, elongate ridge, elongate crenulate socket. Left valve complementary. Inner margin, broad at anterior and posterior, large vestibules. Marginal pore canals, numerous, slightly curved, some false. Central muscle scars circular group of three rows with three scars per row. Upper row has irregular scars, middle row has horizontally elongate scars, bottom row with two elliptical and one vertically elongate scar.

HOLOTYPE: HVH 9437, figured specimen, LV, length 1.13 mm, height .51 mm.

PARATYPES: HVH 9438, figured specimen, RV, length 1.26 mm, height .55 mm; HVH 9439, RV, length 1.13 mm, height .51 mm; HVH 9440, LV, length 1.13 mm, height .53 mm; HVH 9441, carapace, length 1.05 mm, height .51 mm, width .50 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°29.4'N, 92°08.4W, station 97 of this study.

DIMENSIONS: Length 1.05-1.26 mm; height .50-.59 mm.

MATERIAL: Louisiana continental shelf, 16 specimens including nine adult valves and four

juvenile valves. Florida Keys, 30 specimens, including two adult carapaces, 20 adult valves, and seven juvenile valves.

REMARKS: This species differs from *Macrocypris decora* Brady, 1880, by its lateral dorsal outline, made up of four straight line segments, and by the overlap of the right valve by the left at mid-length on the dorsum. The dorsum of *Macrocypris decora* is rounded and the left valve does not overlap the right at the highest point. *Macrocypris schmitti* Tressler, 1949, is more elongate, is higher at the anterior, and has a more rounded posterior. *Macrocyprina propinqua* Triebel, 1960, differs in the shape of the central muscle scars, is more rounded posteriorly, in dorsal view, and lacks dorsal overlap by the left valve. *M. propinqua* also has a higher length/height ratio.

This species is named in honor of Dr. Hubert C. Skinner of Tulane University for his patient supervision of this research.

OCCURRENCE: Stations 70, 97, 98, and 103; Florida Keys.

ECOLOGY: Water depths of 108 to 138 feet; silty clays and clayey silts; foraminiferal P/B ratios of .02 to .13.

Superfamily CYPRIDACEA Baird, 1845
Family CANDONIDAE Kaufman, 1900
Genus CANDONA Baird, 1845

CANDONA sp.
Plate 1, figure 4

Candona lactea Baird. SWAIN, 1955, p. 608, pl. 59, figs. 2a-c; text fig. 38: 1. BYRNE *et al.*, 1959, p. 24, pl. 6, fig. 7. (Not *Candona lactea* Baird, 1850, p. 225, pl. 18, figs. 25-27.)

DIMENSIONS: Right valve, length .70 mm; height .41 mm; left valve, length .77 mm; height .40 mm.

REMARKS: This species is similar to forms previously identified on the Gulf Coast by Swain (1955) and Byrne *et al.* (1959). *Candona lactea* Baird is more rectangular in lateral outline than this species.

OCCURRENCE: Stations 46, 119, and 120.

ECOLOGY: Water depths of 14 to 78 feet; clayey silts and sand; foraminiferal P/B ratios of .005 to .02. Two of the stations are in waters with fully marine salinities (Stations 46 and 119) and the other is in brackish water. Previously reported from brackish waters of San Antonio Bay, Texas.

Family PARACYPIDIDAE Sars, 1925
Genus PARACYPRIS Sars, 1866

PARACYPRIS sp.
Plate 1, figure 7

Paracypris polita Sars. CURTIS, 1960, p. 478, pl. 1, fig. 28. (Not *Paracypris polita* Sars, 1866, p. 12.)

DIAGNOSIS: Characterized by its large size, evenly rounded anterior, pointed posterior, broadly arched dorsum, poorly developed dorsal flange on the left valve, numerous complex marginal pore canals, and wide anterior and posterior vestibules.

DESCRIPTION: Thinly calcified, large, elongate subtriangular in lateral view, greatest height at mid-length, Dorsal margin is broadly arched with slight concavity in posterior one-fourth. Anterior margin broadly rounded, posterior bluntly pointed. Ventral margin is concave at mid-length, slightly concave behind. Dorsal view: greatest width just in front of mid-length. Surface is smooth.

Internal view: Hinge, left valve, a shallow groove receives sharp edge of right valve. A poorly developed extension of flange of left valve is just in front of hinge groove, opposite weak concavity of right valve. Duplicature, wide at anterior and posterior, narrow ventrally. Wide anterior and posterior vestibules. Marginal pore canals, numerous, short, complex. Central scars not observed.

DIMENSIONS: Adult left valve, length 1.02 mm; height .40 mm.

REMARKS: The six poorly preserved specimens recovered do not justify the naming of a new species at this time. *P. franquesi* Howe and Chambers, 1935, does not have bifurcating marginal pore canals or the greatest height at mid-length. *P. rosefieldensis* Howe and Law, 1936, is smaller, has the hinge groove in the right valve, not in the left, and has the greatest height anterior to mid-length. *P. choctawhatcheensis* Puri, 1953, has a few simple marginal pore canals and a large projection of the flange in front of the hinge of the left valve. *P. polita* Sars, 1866, is lower and less arched with the greatest height anterior of mid-length. *P. kaesleri* Pooser, 1965, differs in having a denticulate margin, being smaller, and having a higher length/height ratio.

OCCURRENCE: Stations 91 and 92.

ECOLOGY: Water depth of 198 and 204 feet; silty clay; foraminiferal P/B ratios of .25 and .35. Previously reported from depths greater than 90 feet under low energy, stable conditions, east of the Mississippi River Delta.

Family PONTOCYPRIDIDAE Müller, 1894
Genus ARGILLOECIA Sars, 1866

ARGILLOECIA POSTEROTRUNCATA
van den Bold, 1966
Plate 1, figure 6

Argilloecia sp.KEIJ (part), 1954, p. 218, pl. 3, fig. 8a; pl. 6. fig. 1, (not pl. 3, fig. 8b).
Argilloecia posterotruncata VAN DEN BOLD, 1966a, p. 18, 19, pl. 1, figs. 1a, b.

DIMENSIONS: Length .43 mm; height .22 mm; width .17 mm.

REMARKS: Curtis (1960) reported *Argilloecia cylindrica* Sars and *A. minor* Müller from the area east of the Mississippi Delta. Those species do not have a distinct posterior cardinal angle and are therefore easily distinguished from *A. posterotruncata.*

OCCURRENCE: Stations 2, 17, 20, 29, 93.

ECOLOGY: Water depths of 150 to 780 feet; silty clays; foraminiferal P/B ratios of .13 to .42. Previously reported from the Gulf of Paria at depths of 216 to 510 feet.

Superfamily CYTHERACEA Baird, 1845
Family BYTHOCYTHERIDAE Sars, 1926
Genus JONESIA Brady, 1866

REMARKS: Van den Bold (1966a) has indicated that this genus does not include *Luvula* Coryell and Fields, 1937, as a junior synonym, as stated by Kesling *in* Moore *et al.* (1961).

JONESIA cf. J. SIMPLEX
(Norman, 1865)
Plate 2, figure 6

?Cythere simplex NORMAN, 1865, *in* BRADY (ed.), 1865, p. 17, pl. 5, figs. 1-4.

DIMENSIONS: Left valve (damaged), length .90 mm; height .35 mm.

REMARKS: The lateral outline, muscle scars, and size of these specimens are similar to *J. simplex* Norman. The damaged condition and limited number of the valves preclude exact identification at the species level.

OCCURRENCE: Stations 7, 9, 71, and 102.

ECOLOGY: Water depths of 114 to 198 feet; sand-silt-clay, clayey silt, and silty clay; foraminiferal P/B ratios of .02 to .41.

Genus PUMILOCYTHERIDEA
van den Bold, 1963

PUMILOCYTHERIDEA cf. P. SANDBERGI
van den Bold, 1963
Plate 2, figure 7

Pumilocytheridea sandbergi VAN DEN BOLD, 1963, p. 382, 383, pl. 4, figs. 3a-d; pl. 12, figs. 1a-d, 2a, b.

DIMENSIONS: Carapace, ?female, length .38 mm; height .17 mm; width .15 mm; ?male, length .40 mm; height .17 mm; width .15 mm.

REMARKS: These specimens do not have the strongly developed horizontal ridges present on the figured specimen in van den Bold's study (1963, Plate 4, Figure 3a). The horizontal ridges are variably developed but the subvertical ridge is distinct. This species differs from *Pumilocytheridea ayalai* Morales, 1966, by its distinct posterior cardinal angle and the four ridges parallel to the anterior and ventral margins.

This species was collected near the Louisiana coast, previously, by Philip Sandberg (van den Bold, 1963).

OCCURRENCE: Stations 7, 25, and 115.

ECOLOGY: Water depths of 54 to 192 feet; sand-silt-clay and silty clay; foraminiferal P/B ratios of .04 and .10.

Subfamily KRITHINAE Mandelstam
in Bubikan, 1958
Genus KRITHE Brady, Crosskey,
and Robertson, 1874

KRITHE cf. K. PRODUCTA
Brady, 1880
Plate 3, figure 3

Krithe producta BRADY (part), 1880, p. 114, 115, pl. 27, figs. 1a-d (*not* figs. 1e-j). KEIJ (part), 1954, p. 220, pl. 4, fig. 3; pl. 6, fig. 3b (*not* fig. 3a). CURTIS, 1960, p. 478, pl. 1, fig. 23. VAN MORKHOVEN, 1963, p. 344. YASSINI, 1969, p. 82, Not *Krithe* aff. *K. producta* Brady. VAN DEN BOLD, 1958, p. 398, pl. 2, fig. 3a-d.

DIMENSIONS: Right valve, female, length .60 mm; height .35 mm; left valves, male, length .62-.66 mm; height .33-.34 mm.

REMARKS: These specimens differ slightly from *K. producta* Brady by their parallel dorsal and ventral margins and less convex venter. In juveniles, there appears to be a slight overlap of the left valve, unlike *K. producta*. *K. bartonensis* (Jones), *K. morkhoveni* van den Bold, and *K. cubensis* van den Bold differ in lateral outline. *K. reversa* van den Bold has a different outline of the anterior vestibule. This species differs from *K. dolichodeira* van den Bold by having a sinuous inner margin at the posteroventral region, a more highly arched dorsal margin, longer radial pore canals (twice as long) at the anterior, in being larger and in having the greatest height in front of mid-length.

OCCURRENCE: Stations 17, 20, 64, 92, 94, and 98.

ECOLOGY: Water depths of 69 to 788 feet; silty clays; foraminiferal P/B ratios of .05 to .60. Previously reported from depths of about 90 to 11,000 feet.

Genus PARAKRITHELLA Hanai, 1961

PARAKRITHELLA sp.
Plate 3, figure 5

DIAGNOSIS: Distinguished by its long, low, lateral outline, evenly rounded anterior, posterior obliquely rounded above mid-height, and large rounded anterior vestibule.

DESCRIPTION: Fragile, subcylindrical. Dorsal and ventral margins sub-parallel, both slightly convex, venter has minor concavity in front of mid-length. Anterior broadly rounded; posterior obliquely rounded above, evenly rounded below. Surface is smooth.

Internal view: Hinge, right valve, a shallow longitudinal groove with crenulations at the posterior cardinal angle. Marginal area, wide at anterior, narrow at posterior. Anterior vestibule is wide, with serrated dorsal edge and smooth ventral edge. Apparently there is no posterior vestibule. Radial pore canals are few, simple, some false. Central muscle scars, a vertical row of four; upper three elongate, bottom scar triangular; "U"-shaped frontal scar and elongate madibular scar.

DIMENSIONS: Adult, right valve; length .57 mm; height .23 mm.

REMARKS: This species is similar to *Krithe* sp. McKenzie and Swain, 1967, but differs by having an evenly rounded anteroventral outline, simple radial pore canals, and in the shape of the frontal muscle scar. *Krithe vicksburgensis* Howe and Law, 1936, differs in lateral outline and muscle scar pattern. *Parakrithella* sp. van den Bold, 1963, has a similar outline but a ventrally constricted anterior vestibule.

OCCURRENCE: Stations 70, 89, 91, and 96.

ECOLOGY: Water depths of 138 to 198 feet; silty clays; foraminiferal P/B ratios of .10 to .41.

Subfamily NEOCYTHERIDEINAE Puri, 1957
Genus NEOCYTHERIDEIS Puri, 1952

NEOCYTHERIDEIS cf. N. CYLINDRICA (Brady, 1868)
Plate 3, figure 6

Cytherideis cylindrica BRADY, 1868, p. 113, pl. 13, figs. 11, 12. *Sahnia* aff. *S. subulata* (Brady). CURTIS, 1960, p. 478, pl. 1, fig. 34.

DESCRIPTION: Elongate, subcylindrical, fragile. Left valve, lateral view, dorsal margin is nearly straight with slight convexity just behind mid-length. Ventral margin nearly straight and sub-parallel to dorsum. Anterior margin evenly rounded; posterior acutely rounded with greatest length in lower one-third. Small denticulations on lower posterior margin. Surface has poorly defined horizontal ribs; pits below some ribs give reticulate appearance, especially on posterior one-third of valve. A vertical sulcus is near center of valve; shallow depression below posterior cardinal angle.

Internal view: Some internal features are destroyed by poor preservation. Hinge, left valve, apparently a medial anti-slip bar as described by van Morkhoven (1963); terminal elements not seen. Marginal areas damaged, but selvage is clearly parallel to margin at posterior. Radial pore canals and muscle scars not observed.

DIMENSIONS: Left valve, length .62 mm; height .21 mm.

REMARKS: Curtis reported a similar form from the Mississippi Delta area but considered the form to be a species of the genus *Sahnia* Puri. Van Morkhoven (1963) stated that "In *Sahnia* the posterior end is longest in its upper half, in *Neocytherideis* the maximum length lies in the ventral half." Curtis's figured specimen (1960, Plate 1, Figure 34) and those examined here have the greatest length below mid-height; they are herein considered to be a species of *Neocytherideis*.

OCCURRENCE: Station 7.

ECOLOGY: Water depth of 192 feet, sand-silt-clay; foraminiferal P/B ratio of .07.

Genus CUSHMANIDEA Blake, 1933

CUSHMANIDEA sp.
Plate 3, figure 4

DIAGNOSIS: Distinguished by its arched dorsum, weak anterior denticulations, low anterior and ventral ribs concentric with the margins, weak reticulations, and absence of dorsal sulcus; small size.

DESCRIPTION: Elongate, fragile, small. Dorsal margin arched; ventral margin concave near middle; greatest height at mid-length. Anterior margin, obliquely rounded above, broadly rounded below, weakly denticulate. Posterior margin, broadly rounded. Surface has low weak ribs on anterior and venter, ribs concentric with margins; poorly defined reticulations on posterior one-third of carapace above ventral ribs.

Internal view: Hinge weakly developed; right valve, an anterior curved bar that is the culmination of the selvage and terminates at mid-length. A shallow groove extends from mid-length to posterior cardinal angle. (More posterior elements were not seen as single ?adult specimen is broken). Left valve, an anterior shallow groove to mid-length, followed by a low bar, and shallow elongate socket to posterior cardinal angle. Marginal areas are narrow; no vestibules observed. Marginal pore canals, few and widely spaced. Central muscle scars, a sub-vertical row of four ovate scars with a "V"-shaped frontal scar.

DIMENSIONS: ?Adults, right valve, length .39 mm; height .19 mm; left valve, length .42 mm; height .20 mm.

REMARKS: The small size and weakly developed hingement indicates that all specimens may be juveniles. It is certain they are not juveniles of any other species reported in this study as comparisons with juveniles of each species were made.

Cushmanidea echolsae (Malkin) of Williams (1966) and of McLean (1957) are similar in lateral outline but are much larger and not reticulate on the posterior. The forms reported by Williams and McLean differ from Malkin's original description (1953) and Doris Malkin Curtis (1960) did not positively identify *C. echolsae* from the Mississippi Delta region.

OCCURRENCE: Stations 1, 3, 4, 7, 9, 51, 112, and 115.

ECOLOGY: Water depths of 42 to 174 feet; sand-silt-clay and clayey silt; foraminiferal P/B ratios of .01 to .13.

Genus HULINGSINA Puri, 1958

HULINGSINA ASHERMANI
(Ulrich and Bassler, 1904)
Plate 2, figure 5

Cytherideis ashermani ULRICH and BASSLER, 1904, p. 126, pl. 37, figs. 10-16.

Cushmanidea ashermani (Ulrich and Bassler). HALL, 1965, p. 39, pl. 12, figs. 14-18.

Hulingsina ashermani (Ulrich and Bassler). PURI, 1958a, p. 173, table 2. POOSER, 1965, p. 45, pl. 6, fig. 5; pl. 8, figs. 1-3. HULINGS and PURI, 1965, p. 323, fig. 12a. MCLEAN, 1966, p. 74, pl. 23, fig. 4. GROSSMAN, 1967, p. 68. pl. 14, fig. 2; pl. 20, figs. 13, 14 (with synonymy).

Pontocythere ashermani (Ulrich and Bassler). HULINGS, 1966, p. 51, figs. 2a-g, 6n. SWAIN, 1968, p. 10, pl. 2, figs. 1a-d; pl. 6, fig. 4; text fig. 8. HULINGS, 1967, p. 645, fig. 5e.

DIMENSIONS: Carapaces, length .75-.82 mm; height .35-.37 mm; width .32-.36 mm.

REMARKS: These specimens are generally smaller than the type material of Ulrich and Bassler (1904) and the specimens recovered by Benson and Coleman (1963) from the eastern Gulf of Mexico. The dimensions given for this species by Pooser (1965) agree with the range reported here.

OCCURRENCE: Stations 4, 7, 9, 25, 45, 62, 70-75, 79, 81-84, 87-92, 97-107, 112, and 114.

ECOLOGY: Water depths of 42 and 204 feet; clayey silt and silty clays; foraminiferal P/B ratios of .01 to .41. Previously reported from brackish and marine conditions to depths of 300 feet.

HULINGSINA TUBERCULATA Puri, 1958
Plate 2, figure 8

Hulingsina tuberculata PURI, 1958, p. 173, pl. 2, figs. 5-8. HOWE, 1961, *in* MOORE *et al.* p. Q290, fig. 217, 1a-c.

Cushmanidea tuberculata (Puri). HALL, 1965, p. 39, pl. 13, figs. 1-10.

DIMENSIONS: Right valves, length .73-.80 mm; height .32-.35 mm; left valves, length, .71-.78 mm; height .31-.34 mm.

REMARKS: In the original description of this species, Puri (1958) indicated that the line of concresence coincided with the inner margin. Hall, 1965, reported specimens having a small anterior vestibule; those in this study have a vestibule also. As that is

the only described difference, these specimens are considered to be conspecific with *H. tuberculata* (Puri). In juveniles, even early stages can be identified because this species has small tubercles whereas *H. ashermani* has pits.

OCCURRENCE: Stations 49, 62, 63, 70, 87, 89, 91-93, 95, 96, 98 and 109.

EOCLOGY: Water depths of 72 to 204 feet; clayey silt and silty clays; foraminiferal P/B ratios of .01 to .60. Previously reported from shallow marine waters of less than 10 feet in depth.

Family CYTHERURIDAE Müller, 1894
Genus CYTHERURA Sars, 1866

CYTHERURA SANDBERGI Morales, 1966
Plate 3, figure 1

Cytherura johnsoni Mincher. SWAIN, 1955, p. 627, pl. 64, figs. 8a-c; text figs. 35b, 38: 8a-b; 39: 1a-c. PURI and HULINGS, 1957, p. 187, pl. 87, fig. 11. PURI, 1960, p. 114, pl. 4, figs. 14, 15. BENSON and COLEMAN, 1963, p. 31, pl. 6, figs. 1-5; text figs. 18a, b. (Not *Cytherura johnsoni* Mincher, 1941, p. 343, pl. 47, figs. 1a-d).

Cytherura johnsoni Mincher?. VAN DEN BOLD, 1963, p. 395, pl. 9, fig. 3.

Cytherura sandbergi MORALES, 1966, p. 50, 52, pl. 4, figs. 6a-d. KRUTAK, 1971, p. 20, 21, pl. 2, figs. 3a, b.

DIMENSIONS: Carapace ?male, length .47 mm; height .28 mm; width .24 mm.

REMARKS: Morales (1966) stated that "*Cytherura johnsoni* differs from *C. sandbergi* by having nearly straight, subparallel dorsal and ventral margins, broadly rounded anterior, ornamentation mostly reticulate without strong longitudinal ridges, caudal process in the left valve, and by lacking a loop of the inner lamella in the posterior region." Specimens in this study have caudal processes that are unequal in the right and left valve as described by Morales for *C. johnsoni* Mincher. All other characters, listed above for *C. johnsoni,* can be used to distinguish that form from the specimens reported here.

C. johnsonoides Swain, 1967, differs from this species by its coarsely reticulate surface and position of the caudal process at mid-height. The dorsum of *C. luciae* van den Bold, 1966, is more highly arched and the caudal process is in a medial position, in contrast to *C. sandbergi.*

OCCURRENCE: Stations 1, 54, 56, 59, 114, and 115.

ECOLOGY: Water depths of 44 to 144 feet; clayey silt and sand; foraminiferal P/B ratios of .01 to .02. Previously reported from brackish and marine waters at depths of 10 to 180 feet.

CYTHERURA SWAINI
van den Bold, 1963
Plate 3, figure 2

Cytherura swaini VAN DEN BOLD, 1963, p. 396, pl. 9, figs. 4a, b. MORALES, 1966, p. 53, pl. 4, fig. 2.

DESCRIPTION: Internal view, left valve; anterior hinge element damaged; medial element, a thin bar at mid-length, displaced toward interior at posterior cardinal angle where it forms a small elongate knob, followed by a small elongate socket that tapers to a point posteriorly. Inner lamella, widest at anterior, narrow near oral region, widens behind mid-length and merges into caudal process. Line of concresence coincides with inner margin. A few scattered marginal pore canals were seen at the anterior; they are apparently straight. Muscle scars not seen.

DIMENSIONS: Left valve, length .34 mm; height .14 mm.

MATERIAL: Two right valves.

REMARKS: A partial description of the internal features of the left valve is included here to supplement previous reports of this species.

OCCURRENCE: Stations 98 and 115.

ECOLOGY: Water depths of 54 and 138 feet; clayey silts; foraminiferal P/B ratios of .01 to .07. Previously reported from brackish and marine waters at depths of 10 to 180 feet.

CYTHERURA sp. A
Plate 3, figure 7

DIAGNOSIS: Distinguished by its long low carapace, high and narrow longitudinal ribs, and the small pointed caudal process.

DESCRIPTION: Fragile, medium size. Lateral view, elongate ovoid. Dorsal margin, low, smooth, convex. Ventral margin, sinuate, concave in front of mid-length, convex behind. Greatest height at mid-length. Anterior margin acutely rounded; posterior margin more broadly rounded above and below caudal process. Caudal process is pointed, upturned, located just above mid-height. Surface has about 12 high and narrow longitudinal ribs;

dorsal and ventral ribs are high and distinct, and continuous with anterior rim; dorsal rib continues onto caudal process, ventral rib less distinct at extreme posterior; several lateral ribs continue to posterior; first and third below dorsal rib, and fourth and seventh ribs join near anterior, then proceed as a single rib to join anterior rim. Several lateral ribs join near posterior to form a broad loop. Faint vertical ribs give the appearance of reticulations at high magnification (about 150X).

Internal view: Hinge, right valve, typical of genus; terminal teeth are crenulate; medial groove long, smooth, widens and deepens anteriorly, slightly expanded posteriorly. Inner lamella narrow; line of concrescence coincides with inner margin. Selvage is low, parallel to outer margin, sharply turned upward just in front of mid-length at venter. Muscle scars not seen.

DIMENSIONS: Right valve, length .50 mm; height .25 mm.

MATERIAL: Two right valves, one left valve.

REMARKS: This species differs from *C. forulata* Edwards, 1944, by having a higher length/height ratio, non-parallel dorsal and ventral margins, the caudal process above mid-height, and an acutely rounded anterior margin. This species is not named because of the limited number of specimens.

OCCURRENCE: Stations 4, 5, and 9.

ECOLOGY: Water depths of 108 to 186 feet; sand-silt-clay; foraminiferal P/B ratios of .02 to .13.

CYTHERURA sp. B
Plate 3, figure 8

DIAGNOSIS: Distinguished by its long low carapace with subparallel dorsal and ventral margins, and posteroventral rib forming an alate-like projection that obscures the margin in lateral view.

DESCRIPTION: Subrectangular in lateral view, delicate, small. Dorsal margin nearly straight, ventral margin sub-parallel with slight concavity just behind anterior margin. Anterior margin evenly rounded above and below. In the left valve, the caudal process forms most of the posterior margin from about mid-height to the dorsum; in the right valve the caudal process is smaller and pointed. Surface is ornamented by low ribs on the dorsal area, high delicate ribs and cross ribs forming reticulations on posteromedial surface; the posteroventral rib is high, delicate, and undulating and obscures the margin in lateral view. An undulating vertical rib in front of the highly produced posterior connects the posteroventral rib with several lateral ribs. A few lateral ribs reach the thin anterior rim. An eyespot is present. ?Males are lower than ?females (length/height ratios are 2.6 and 2.0 respectively).

Internal view; Hinge, right valve, an anterior knob-like tooth and long shallow crenulate medial groove with expanded ends opening into interior of valve. Inner lamella is wide at anterior, narrow elsewhere. Radial pore canals and muscle scars obscured.

DIMENSIONS: ?Female, right valve, length .50 mm; height .25 mm; ?male, right valve, length .45 mm; height .21 mm.

MATERIAL: Five valves.

REMARKS: Although muscle scars and the marginal areas were obscured because of the opaque nature of the valves, the shape of the valves and dentition are characteristics of the genus *Cytherura.* Ornamentation and outline easily distinguish this form from *Cytherura* sp. A. of this report. *Cytherura wardensis* Howe and Brown, 1935, has a finely reticulate surface but neither high ribs nor an ala-like posteroventral rib. *C. forulata* Edwards, 1944, and *C. elongata* Edwards, 1944, differ by having weak ornamentation, no strong posteroventral or subvertical ribs. This species is not named because of the limited number of specimens.

Curtis (1960) reported *Cytherura* cf. *paradoxa* Müller from the delta region, but that species is not ribbed over the entire surface.

OCCURRENCE: Stations 3 and 7.

ECOLOGY: Water depths of 174 to 192 feet; sand-silt-clay; foraminiferal P/B ratios of .05 and .07.

Genus CYTHEROPTERON Sars, 1866

CYTHEROPTERON HAMATUM Sars, 1866
Plate 3, figure 8

Cytheropteron hamatum SARS, 1866, p. 172. BRADY and NORMAN, 1889, p. 212, pl. 20, figs. 13-15. SARS, 1927, p. 226, pl. 104, fig. 2. YASSINI, 1969, p. 101, pl. 21, fig. 9; pl. 22, fig. 6.

Cytheropteron aff. *C. alatum* Sars. CURTIS, 1960, p. 478, pl. 1, fig. 13. (Not *Cytheropteron alatum* Sars, 1866, p. 82).

?Cytheropteron sp. aff. *hamatum* Sars. VAN DEN BOLD, 1966a, p. 33, 34, pl. 3, figs. 2a, b.

?Cytheropteron sp. aff. *hamatum* Sars. VAN DEN BOLD, 1966b, p. 171, figs. 6a,b.

DIAGNOSIS: Distinguished by its reticulate and furrowed medial and posterior surface, alae with sharp lateral spines, and a single sharp spine on posterior edge of each ala.

DESCRIPTION: Lateral view, elongate ovate; moderately calcified, small. Dorsal margin general-

ly convex but slightly sinuous with concavity about one-fourth of length from posterior. Ventral margin is sinuous, being concave just in front of mid-length, broadly convex behind. Anterior margin, acutely rounded. Posterior margin has bluntly rounded caudal process above mid-height, broadly rounded below. Right valve more highly arched than left: left valve higher at anterior portion of caudal process and forms carapace outline at caudal process. Caudal process in right valve is upturned and in left is straight. Left valve is larger than right except at dorsum where right valve is higher.

Dorsal view: Arrow shaped, alar margins nearly parallel. Sharp spines at greatest width (on posterolateral edge of alae) are nearly perpendicular to carapace. A sharp spine is on posterior edge of ala. Anterior acutely rounded, extreme posterior highly compressed. Greatest length formed by left valve; right valve higher at dorsum but left valve overlaps right at anterior cardinal angle. An elongate depression exists left of dorsal valve contact. A large broad pit is on top of ala surface. Ventral view, line of contact sinuous in front of mid-length; alar surfaces have low narrow ridges that join to form loops pointing to posterior.

Surface: Punctate to reticulate and furrowed. Anterior marginal area has low rim. Anterior one-third with punctae increasing in coarseness toward alae. Median lateral and alar surfaces are coarsely punctate to reticulate; reticulations are elongate vertically with vertical ridges dominant; cross ridges distinct but delicate. Posterodorsal surface, sub-vertical furrows with small indistinct cross ridges. A large irregular pit at middle of upper ala surface.

Extreme forward edge of ala has two low ridges that form a loop just in front of greatest width. Lateral and posterior spines on alae are sharp and joined to lateral surface by a ridge. Dimorphic features, females are higher than males.

Internal view: Valves deep with an oval pit in muscle scar area. Hinge, right valve, anterior element is a large oval tooth; medial element an arched, coarsely crenulate groove, enlarged at both ends; posterior element, an elongate-ovate weakly crenulate tooth. Anterior and posterior teeth appear to be extentions and enlargements of selvage. Above medial groove and forming its dorsal border is a heavy ridge; bottom of medial groove closed with a weak ridge in some specimens. Hinge, left valve, anterior element is a large oval socket that is closed ventrally with a thin ridge; medial element, a coarsely crenulate ridge that thickens at each end. Posterior end of medial ridge has a large rounded positive element followed by a deep oval socket.

The inner lamella is wide at the anterior and posteroventral areas. There is a small anterior vestibule; line of concresence is parallel to the outer margin. Marginal pore canals, few, simple, most are false. The inner opening of a marginal pore canal is enlarged, often with two canals joining at line of concresence. Selvage, submarginal except anteroventrally where it is displaced, forming a high raised edge. Muscle scars not clear because of ornamentation; seems to be a subvertical row of four, upper three elongate, lowest is circular and divided. Frontal scar horizontal "U"-shaped, open to front.

DIMENSIONS: ?Females, right valve, length .40-.43 mm; height .22-.25 mm.

REMARKS: This species differs from *Cytheropteron morgani* Kontrovitz, n. sp., by having two spines on each ala, nearly parallel sides in dorsal view, a more coarsely ornamented carapace, and heavier dentition. *Cytheropteron* sp. van den Bold, 1967, does not have two spines on each ala, is not reticulate, and is larger (length .47 mm; height .25 mm).

C. paralatissimum Swain, 1963, is similar in lateral outline but does not have two spines on each ala. Swain's species is larger, has less pronounced ornamentation, and has a different muscle scar pattern. *C. alatum* Sars, 1866, has a different lateral outline and appears to have a smooth surface.

OCCURRENCE: Stations 1, 7, 9, 25, 28-31, 41, 44, 50, 64, 67, 86, 103, 113.

ECOLOGY: Water depths of 66 to 306 feet; sediments varied from sand-silt-clay to silty clay and clayey silt; foraminiferal P/B ratios of .01 to .26. Previously reported from depths of about 90 to 10,000 feet.

CYTHEROPTERON MORGANI
Kontrovitz, n. sp.
Plate 3, figures 10-11

?Cytheropteron aff. *C. latum* Müller, CURTIS, 1960, p. 478, pl. 1, fig. 13. (Not *Cytheropteron latum* Müller, 1894, p. 300, 301, pl. 20, figs. 3, 9; pl. 21, figs. 10-11).

DIAGNOSIS: Distinguished by its sharply pointed alae, furrowed and pitted medial and posterior surfaces, divided lower adductor muscle scar, and a "U"-shaped frontal muscle scar with the open end forward.

DESCRIPTION: Carapace ovate in lateral view, strongly alate, small, moderately calcified. Dorsal margin slightly arched, anterior cardinal angle indistinct; ventral margin sinuate with concavity just in front of mid-length. Anterior margin acutely rounded below mid-height, broadly rounded above. Posterior margin, caudal process above mid-height and slightly upturned; margin broadly rounded below process. Left valve is larger than right; right valve is convex at anterior cardinal angle, left valve is smoothly arched. Caudal process of left valve forms carapace outline, the process of the right valve has less vertical extent and is more pointed.

Dorsal view: Arrow shaped, extremities of alae are nearly perpendicular to carapace. Anterior is compressed, posterior is bluntly rounded. Distinct overlap by left valve at anterior cardinal angle. A low ridge on right valve is nearly parallel to hinge area.

Ventral view: Distinct overlap by right valve just in front of mid-length. A series of ridges, especially prominent in mid-ventral area, are nearly parallel to outer edge of valves.

Surface: Ornamentation, behind middle, subvertical pitted furrows. Some specimens have weak cross ridges forming reticulations. Anterior edge of ala has low rounded ridges parallel to that edge. A few low ridges on posterior surface of ala; one ridge sometimes follows posterior edge of ala to a position below posterior cardinal angle, there forming a loop. There is a large vertical pit on upper anterior ala surface (below and posterior to central muscle scars).

Internal view: Hinge, right valve, anterior element small, rounded; a medial, slightly sinuate, crenulate groove with coarser crenulations at each end; posterior tooth is elongate, crenulate, and part of selvage. Dorsal part of medial groove is closed by a heavy ridge, bottom is closed by weak ridge. Left valve, complementary, with an anterior indistinct rounded socket, followed by a sinuous crenulate bar, and posterior elongate socket (apparently not crenulate).

Inner lamella, wide at anterior and posterior. Anterior vestibule is moderately wide and with a scalloped line of concrescence; elsewhere line of concrescence equals inner margin. Marginal pore canals are few, simple, and some are clustered about indentations in line of concrescence. Selvage is low at anterior and parallel to margin, closer to anteroventral margin; it turns inward just behind mid-length and diverges from outer margin in posterior portion of valve. Central muscle scars form a subvertical row of four scars; top three are elongate-ovate, bottom is divided into two ovate scars: Frontal scar, "U"-shaped, open to front. Apparently, a single rounded mandibular scar is located just above anterior edge of ala.

HOLOTYPE: HVH 9471, figured specimen, LV, length .52 mm, height .28 mm.

PARATYPES: HVH 9472, LV, length .51 mm, height .28 mm; HVH 9473; figured specimen, RV, length .48 mm, height .28 mm; HVH 9474, damaged carapace, length .46 mm; height .26 mm, width .36 mm; HVH 9475, LV, length .52 mm, height .28 mm.

TYPE LOCALITY: Louisiana continental shelf, 29°27.0'N, 88°40.2'W, station 4 of this study.

DIMENSIONS: Carapaces, ? female, length .48 mm; height .28 mm, width .35 mm (alae damaged); ?male, length .50 mm; height .27 mm; width .38 mm.

MATERIAL: Adults, three carapaces, 62 valves; juveniles, two carapaces, seven valves.

REMARKS: *Cytheropteron paralatisimum* Swain, 1963, differs by having only weak crenulations of the medial hinge groove of the right valve, fewer marginal pore canals, its larger size, and different central muscle scar pattern. *Cytheropteron* sp. van den Bold, (1967b) has a smoother surface and persistent ridges related to the anterior and posterior edges of the alae.

C. alatum Sars, 1866, has a smooth lateral surface, is larger, and has several distinct elongate depressions on the forward edge of each ala. *C. latum* Müller has a pitted but unfurrowed surface.

This species is named in honor of Dr. James P. Morgan of Louisiana State University; he provided 23 of the samples used in this study.

OCCURRENCE: Stations 4, 5, 7, 25, 46, 69-71, 73, 76, 81, 83, 88, 91, 92, 96, 97, 102, 106, 107, 109, and 111.

ECOLOGY: Water depths of 78 to 204 feet; sediments varied from clayey silt to

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PLATE 1

Figure Page

1. *Neonesidea* sp., HVH 9436, damaged left valve (100X) 58
2-3. *Macrocyprina skinneri* Kontrovitz, n. sp. 58
2. Holotype, HVH 9437, left valve (60X)
3. Paratype, HVH 9438, right valve (60X)
4. *Candona* sp., HVH 9442, left valve (60X) 59
5. *Candona* cf. *C. patzcuaro* Tressler, HVH 9443, right valve (60X) 93
6. *Argilloecia posterotruncata* van den Bold, HVH 9444, right valve (70X) 60
7. *Paracypris* sp., HVH 9445, right valve (60X) 79
8. *Candona* cf. *C. marchina* Hartwig, HVH 9446, right valve (100X) 93

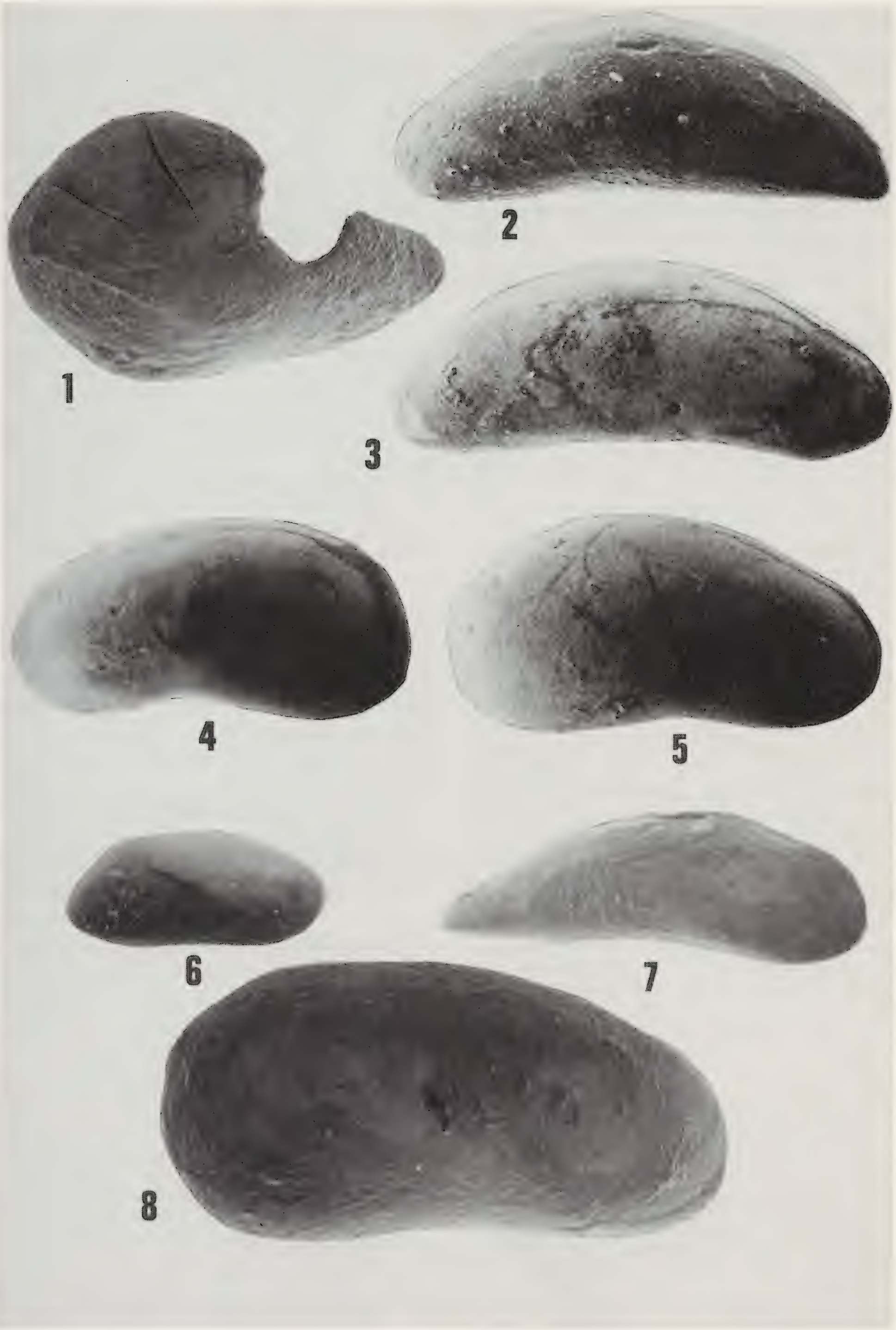

PLATE 1

silty clay and sand-silt-clay; foraminiferal P/B ratios of .01 to .60.

CYTHEROPTERON TUMULOSIMILIS Kontrovitz, n. sp.
Plate 4, figures 1, 2

Cytheropteron leonensis Puri. CURTIS, 1960, p. 478, pl. 1, fig. 12. (Not *Cytheropteron leonensis* Puri, 1954, p. 242, pl. 4, figs. 11, 12; text figs. 6a, d).

DIAGNOSIS: Distinguished by its dome-like (triangular) lateral shape, reticulate lateral surface, and low length/height ratio of less than 1.55.

DESCRIPTION: Dome-like or triangular in lateral view with low alae; moderately calcified, small. Dorsal margin highly arched; ventral margin is nearly straight with concavity just in front of mid-length; greatest height is just in front of mid-length. Anterior and posterior margins, acutely rounded below mid-height, more broadly rounded above. Extreme posterior is compressed and slightly produced. Left valve is larger than right except at dorsum behind mid-length. Sexual dimorphism not observed.

Dorsal view: sub-ovate, sides subparallel. Anterior and posterior are bluntly rounded; left valve overlaps right at one-third of length from anterior; right valve overlaps left just in front of mid-length. Greatest width is just behind middle.

Surface: Striate, reticulate. Upper surface of low ala has about three low ridges parallel to alar edge; a few indistinct cross ridges. Lower posteromedial surface is reticulate; posterodorsal surface has low subvertical ridges giving a furrowed appearance. Anterior half of valve has low indistinct irregular ridges. Flattened ventral surface is striate; striae are parallel to nearest outer edge.

Internal view: Hinge, right valve, anterior element an elongate crenulate tooth (in front of greatest height of valve); medial element, a curved crenulate groove that widens at each end with coarsest crenulations at the ends. There is a separate short, narrow, deep groove above the anterior four crenulations of the medial groove. Edge of valve forms a sharp ridge above medial groove. Posterior element is an elongate, slightly crenulate tooth just below posterior cardinal angle. Left valve, complementary, with a large anterior crenulate socket, a medial crenulate bar, and a posterior elongate slightly crenulate socket just below posterior cardinal angle.

Inner lamella moderately wide at anterior, elsewhere narrow. Anterior vestibule, about one-half width of inner lamella. Radial pore canals are short and simple, seven to eight at anterior vestibule; a few are false at upper anterior margin, above the vestibule. A few radial pore canals below mid-height at posterior.

Selvage, right valve, at middle of the anterior portion of inner lamella; displaced upward in front of mid-length at venter, subparallel to margin behind mid-length. Selvage, left valve, posteroventral area, more toward inner margin. A distinct flange forms a narrow groove for reception of selvage of right valve. (A similar groove seen in medial ventral area of right valve receives selvage of left).

Muscle scars, adductors form a row of four, uppermost is elongate and sloping toward anteroventral margin, middle two are elongate and point to anterior margin, lowermost is small and subcircular. Frontal scar obscure but appears to be elongate oval. Two elongate mandibular scars are in front of and below the adductors.

HOLOTYPE: HVH 9476, figured specimen, RV, length .34 mm, height .22 mm.

PARATYPES: HVH 9477, figured specimen, LV, length .34 mm, height .22 mm; HVH 9478, RV, length .34 mm, height .24 mm; HVH 9479, RV, length .34 mm, height .23 mm; HVH 9480, carapace, length .34 mm, height .23 mm, width .20 mm; HVH 9481, LV, length .33 mm, height .21 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°33.0'N, 91°48.6'W, station 70 of this study.

DIMENSIONS: Carapace, length .33 mm; height .22 mm; width .21 mm; right valves, length .32-.35 mm; height .22-.24 mm.

MATERIAL: Adults, one carapace, 12 valves; juveniles, one valve.

REMARKS: This species is similar in outline to *C. leonensis* Puri, 1954, but is easily distinguished by its reticulate lateral surface. *C. leonensis* is striate not reticulate and is larger, measuring about .51 mm in length and .24 mm in height.

?Cytheropteron subreticulatum van den Bold, 1946, has "a forked ridge bordering the posterior side of the ala" (van den Bold, 1966a) not found on the species described here. *?C. subreticulatum* is not coarsely reticulate on the lateral surface and has a length/height ratio of 1.66.

This species is named for its characteristic lateral outline; tumulus is a masculine Latin noun meaning mound, hill, or hillock.

OCCURRENCE: Stations 9, 70, 71, 74, and 82.

ECOLOGY: Water depths of 84 to 138 feet; clayey silts and silty clays; foraminiferal P/B ratios of .02 to .13. Previously reported from the "offshore biofacies" of Curtis (1960), at depths greater than 90 feet.

Genus PARACYTHERIDEA Müller, 1894

PARACYTHERIDEA sp.
Plate 4, figure 3

DESCRIPTION: ?Juveniles, right valve; alate, small. Subtriangular in lateral view. Dorsal margin is nearly straight with slight concavity in middle; ventral margin is sinuous and strongly converging with dorsum. Anterior margin, broadly rounded above, abruptly truncated by ventral margin below. Posterior margin is a long pointed caudal process with a coarse spine below and in front of process. Surface is ornamented by a few coarse ridges and nodes and dominated by a prominent alate process with a sharp point. A sharp ridge extends from anteroventral area to alar process, another ridge from a node at the anterior margin across mid-height and down just in front of ala where it joins the more ventral ridge. After joining, the two ridges then form the forward edge of the ala. There is a coarse node with a few irregular ridges just below posterior cardinal angle.

Internal view: Hinge, right valve, anterior element is a faintly crenulate tooth followed by a medial weakly crenulate groove and posterior weakly crenulate tooth. Inner lamella and muscle scars not observed because of poor preservation of interior.

DIMENSIONS: Right valve, length .38 mm; height .19 mm.

MATERIAL: Five ?juvenile right valves.

REMARKS: The specimens are apparently juveniles and are described for the purpose of comparison with future studies. There is some similarity to *Paracytheridea tschoppi* van den Bold, 1946, but that species has more distinct ornamentation and is larger (.53 mm in length).

OCCURRENCE: Stations 7, 9, and 25.

ECOLOGY: Water depths of 108 to 192 feet; sand-silt,clay and clayey silt; foraminiferal P/B ratios of .04 to .13.

Family HEMICYTHERIDAE Puri, 1953
Subfamily HEMICYTHERINAE Puri, 1954
Genus AURILA Pokorný, 1955

AURILA FLORIDANA
Benson and Coleman, 1963
Plate 4, figure 6

Aurila conradi (Howe and McGuirt) *floridana* BENSON and COLEMAN, 1963, p. 35, 36, pl. 8, figs. 10-12, text fig. 21.

Aurila floridana Benson and Coleman. MORALES, 1966, p. 56, 57, pl. 5, figs. 5a-d (with synonymy).

DIMENSIONS: Carapaces, ?females, length .60-.62 mm; height .41-.42 mm; width, .35-.40 mm; left valve, length .64 mm; height .42 mm.

REMARKS: Morales (1966) stated that *Aurila conradi* (Howe and McGuirt) *littorala* Grossman, 1965, and *A. floridana* are conspecific. *Aurila floridana* has a distinct high, fluted, central rib that is not present on *A. conradi littorala,* thus the two forms can be differentiated. Grossman (1965) also used difference in size as a character to distinguish the two forms just mentioned; specimens in this study are intermediate in size, thus negating the use of that character.

OCCURRENCE: Stations 4, 7, 68-72, 86-88, 92, and 96-99.

ECOLOGY: Water depths of 99 to 204 feet; silty clays and clayey silts; foraminiferal P/B ratios of .02 to .60. Previously reported from depths of less than 135 feet in brackish and marine salinities.

Subfamily THAEROCYTHERINAE
Hazel, 1967
Genus PURIANA Coryell and Fields, *in* Puri, 1953

PURIANA RUGIPUNCTATA
(Ulrich and Bassler, 1904)
Plate 4, figure 5

Cythere rugipunctata ULRICH and BASSLER, 1904, p. 118, pl. 38, figs. 16, 17.

Cythereis rugipunctata (Ulrich and Bassler). HOWE *et al.,* 1935, p. 23, pl. 1, figs. 18, 20-22; pl. 4, figs. 22, 23.

Favella rugipunctata (Ulrich and Bassler). EDWARDS, 1944, p. 524, pl. 88, figs. 5, 6. VAN DEN BOLD, 1950, p. 797, pl. 83, fig. 24.

Trachyleberis? *rugipunctata* (Ulrich and Bassler). SWAIN, 1952, p. 38, pl. 6, fig. 8.

Puriana rugipunctata (Ulrich and Bassler). PURI, 1953, p. 571. PURI, 1954, p. 257, 258, pl. 12, figs. 16, 19; text fig. 8k. MCLEAN, 1957, p. 89, pl. 11, figs. 5a-d. PURI and HULINGS, 1957, p. 174, 176, 183. BROWN, 1958, p. 63, pl. 4, fig. 10. PURI, 1960, p. 126, pl. 6, fig. 18. BENSON and COLEMAN, 1963, p. 43, 44, pl. 8, figs. 1, 2, 5; text fig. 27. POOSER, 1965, pl. 17, figs. 4-7, 9. HULINGS and PURI, 1965, p. 321, fig. 12. VAN DEN BOLD, 1965, p. 399. MCLEAN, 1966, p. 69, 70. WILLIAMS, 1966, p. 33, fig. 18, no. 9; fig. 27. GROSSMAN, 1967, p. 77, pl. 14, fig. 8; pl. 21, figs. 11-13. SWAIN and ENGEL, 1967, p. 419, pl. 1, fig. 6. SWAIN, 1968, p. 18, 19, pl. 5, figs. 8a-c; pl. 7, fig. 4; text figs. 16, 17.

DIMENSIONS: Carapace, length .62 mm; height .33 mm; width .36 mm.

REMARKS: This is one of the most widely distributed species in the Tertiary and Quaternary sediments of the eastern United States. The specimens in this study

are smaller than those of Ulrich and Bassler (1904), but are in the size range reported by later authors (Edwards, 1944; Puri, 1954; Swain, 1968).

OCCURRENCE: Stations 7, 53, and 71.

ECOLOGY: Water depths of 60 to 192 feet; sediments were varied from sand-silt-clay to clayey silt and silty clay; foraminiferal P/B ratios of .005 to .07. Previously reported from the Gulf of Mexico in depths to 240 feet and in shoaler brackish and marine waters.

PURIANA KRUTAKI Kontrovitz, n. sp.
Plate 4, figures 9-10

Puriana sp. SWAIN, 1955, p. 635, pl. 63, fig. 10.
Puriana sp. KRUTAK, 1971, p. 15, pl. 4, figs. 4a, 4b.

DIAGNOSIS: Distinguished by its large anterolateral node, sharp anteroventral ridge, sharp anterior rim, nearly smooth anterodorsal margin, isolated spines on posterior half of valves, and absence of any rugose or plicate surface.

DESCRIPTION: Subquadrate, moderately calcified, medium size. Dorsal margin is nearly straight; ventral margin, subparallel, with a convexity in front of mid-length. Anterior margin broadly rounded below mid-height, more acutely rounded above; about five small triangular denticles below mid-height. Posterior margin, broadly rounded below with five heavy elongate denticles in lower two-thirds; upper part acutely rounded. A small spine is above denticulations and a small pointed spine at posterior cardinal angle. Sexual dimorphism was not observed.

Dorsal view: Widest in front of mid-length, corresponding to anterolateral nodes (about two-fifths of length behind anterior); acutely rounded anterior with a rim. Carapace tapers gently from greatest width to posterior cardinal angle; highly compressed behind. Posterolateral areas are spinose in dorsal view.

Ventral view: Elongate depression just in front of mid-length, formed by divergence of distal portions of each valve (flanges). Left valve is slightly larger than right.

Surface: Ornamentation of sharp ridges and blunt lateral spines or tubercles. Sharp, high anterior rim, from small eye tubercle, extends parallel to anterior margin to the convexity on ventral margin and extends to about mid-length. Large rounded anterolateral swelling; highest part of swelling is the most posterior part, lower forward. Some specimens show two short ridges from the swelling toward lower anterior margin, but on other specimens the ridges are not clearly defined. Behind eyespot and above anterolateral swelling, surface is smooth. Posterior half of valves have short, heavy spines that are aligned on some specimens as a lateral row and a posteroventral row. Subdued indistinct spines occur in front of posterior cardinal angle; on a few specimens these are subvertically elongate but are never plicate or rugose.

Internal view: Valves are deep, with a rounded depression that corresponds to external swelling. Marginal areas are moderately wide at anterior and lower posterior; small anterior and posterior vestibules; line of concrescence is serrate in vestibules. Some marginal pore canals enter serrations; a few serrations have more than one marginal pore canal; a few canals are false. Muscle scars are obscured by the opaqueness of the valves.

HOLOTYPE: HVH 9487, figured specimen, carapace, length .55 mm, height .28 mm, width .30 mm.

PARATYPES: HVH 9488, RV, length .58 mm, height .30 mm; HVH 9489, figured specimen, LV, length .55 mm, height .30 mm; HVH 9490, RV, length .53 mm, height .27 mm; HVH 9491, juvenile RV, length .44 mm, height .24 mm; HVH 9492, carapace, length .55 mm, height .28 mm, width .28 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°28.8'N, 91°03.0'W, station 93 of this study.

DIMENSIONS: Carapaces, length .58-.59 mm; height .28-.30 mm; width .28-.31 mm.

PLATE 2

Figure Page

1. *Cyprideis* cf. *C. salebrosa* van den Bold, HVH 9447, left valve (100X) 93
2. *Psuedocythere* aff. *P. fragilis* Sars, HVH 9448, right valve (100X) 93
3. *Haplocytheridea* cf. *H. bradyi* (Stephenson), HVH 9449, left valve (100X) 93
4. *Perissocytheridea excavata* Swain , HVH 9450, right valve (100X) 93
5. *Hulingsina ashermani* (Ulrich and Bassler), HVH 9451, left valve (100X) 62
6. *Jonesia* cf. *J. simplex* (Norman), HVH 9452, damaged left valve (100X) 60
7. *Pumilocytheridea* cf. *P. sandbergi* van den Bold, HVH 9453, right valve (100X) 60
8. *Hulingsina tuberculata* Puri , HVH 9454, left valve (100X) 62

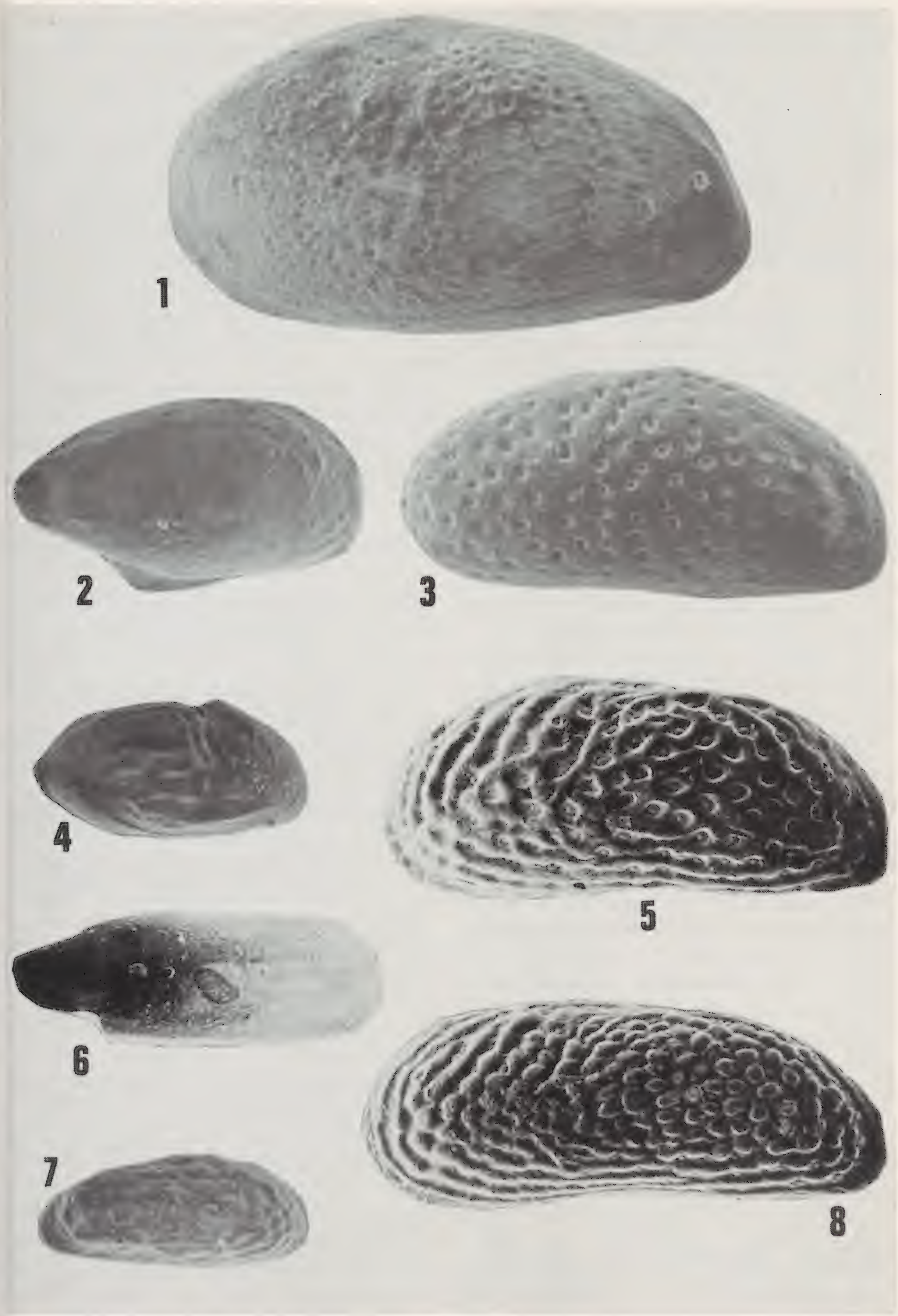

PLATE 2

MATERIALS: Adults, six carapaces, 35 valves; juveniles, two carapaces, four valves.

REMARKS: This species is easily distinguished from *P. rugipunctata* (Ulrich and Bassler) by its ornamentation. *P. pacifica* Benson, 1959, has heavier ornamentation in the posterodorsal area, lacks the sharp ridge at the anteroventral area, is larger, has more posterior denticles, and is more concave on the ventral margin in front of the mid-length.

In juveniles of *Puriana krutaki,* n. sp. the anteroventral rib continues to the posterior and several ribs that cross the central area resemble those of adult specimens of *P. mesocostalis* (Edwards, 1944). Adults of *P. mesocostalis* have distinct ornamentation, however.

Difference in preservation causes varying numbers of posterior denticles to be preserved. Thus, Krutak (1971) reported "four blunt" posterior spines, but it is evident that other denticle bases are present on the posteroventral margins of his specimens.

This species is named in honor of Dr. Paul R. Krutak who first recognized this form as an undescribed species.

OCCURRENCE: Stations 1, 4, 56, 57, 63, 64, 66, 67, 70, 73, 79, 82, 84, 105, 109, 115, and 119.

ECOLOGY: Water depths of 42 to 144 feet; sediments were varied from sand-silt-clay to clayey silt and silty clay; foraminiferal P/B ratios of .01 to .10. Previously reported from marine waters in the open gulf near San Antonio Bay, at depths less than 60 feet (Swain, 1955) and from brackish waters at a five foot depth near Veracruz, Mexico (Krutak, 1971).

Family LOXOCONCHIDAE Sars, 1925
Genus LOXOCONCHA Sars, 1866

LOXOCONCHA cf. L. MATAGORDENSIS Swain, 1955
Plate 5, figure 1

Loxoconcha matagordensis SWAIN, 1955, p. 629, pl. 63, figs. 9a-b; pl. 64, figs. 1a, b; text figs. 36b, 39:7a, b.

DIMENSIONS: ?Male, carapace, length .50 mm; height .29 mm; width .13 mm; ?female, left valve, length .55 mm; height .35 mm.

REMARKS: These specimens resemble *L. matagordensis* Swain but are smaller and poorly preserved. The ornamentation indicates they are related to *L. matagordensis* and perhaps all are juveniles; it would be unusual for only juveniles to be recovered. Grossman (1967) stated that transitional ornamentation on some forms "joins the two species" *L. purisubrhomboidea* (Edwards, 1944) and *L. matagordensis.*

OCCURRENCE: Stations 4, 5, 7, 9, 14, 20, 28-31, 47, 48, 92, 100, and 103.

ECOLOGY: Water depths of 45 to 420 feet; sediments were varied from clayey silts to silty clays and sand-silt-clay; foraminiferal P/B ratios of .005 to .60. Previously reported from shallow, brackish and marine environments, at depths less than 60 feet.

LOXOCONCHA aff. L. PURISUBRHOMBOIDEA Edwards, 1953
Plate 5, figure 2

?*Loxoconcha subrhomboidea* Brady. EDWARDS, 1944, p. 527, pl. 88, figs. 28-32. (Not *Loxoconcha subrhomboidea* Brady, 1880, p. 121, pl. 28, figs. 4a-d.)

?*Loxoconcha purisubrhomboidea* EDWARDS *in* PURI, 1953, p. 270.

Loxoconcha cf. *L. purisubrhomboidea* Edwards. CURTIS, 1960, pl. 1, fig. 21; pl. 2(bottom), fig. 16.

DIMENSIONS: ?Female, length .45 mm; height .29 mm.

REMARKS: The shape and ornamentation are similar to *L. purisubrhomboidea* but poor preservation does not allow exact identification. These species do not have the faint ridges and reticulations of *L.* cf. *L. matagordensis,* reported above.

OCCURRENCE: Stations 30, 31, 33, 39 and 40.

ECOLOGY: Water depths of 130 to 270 feet; sediments varied from sand-silt-clay to clayey silt and silty clay; foraminiferal P/B ratios of .01 to .11. Previously reported from brackish and marine waters at shallow depths; Curtis (1960) reported a form similar to this from depths up to 550 feet east of the modern delta.

LOXOCONCHA MORALESI Kontrovitz, n. sp.
Plate 5, figures 3, 4

Loxoconcha australis Brady. SWAIN, 1955 (part), p. 630, pl. 63, fig. 11 (*not* pl. 64, fig. 2). ENGEL and SWAIN, 1967, p. 413, pl. 1, fig. 12. (Not *Loxoconcha australis* Brady, 1880, p. 119, 120, pl. 28, figs. 5a-f; pl. 29, figs. 3a-c).

?Loxoconcha australis Brady. CURTIS, 1960, p. 478, pl. 2, (top) fig. 12, (bottom) fig. 15.

?*Loxoconcha* cf. *L. australis* Brady. CURTIS, 1960, pl. 3, (top) fig. 4.

Loxoconcha subrhomboidea Brady. CURTIS, 1960, p. 478, pl. 2, (bottom) fig. 12; pl. 3, (top) fig. 5 (Not *Loxoconcha subrhomboidea* Brady, 1880, p. 121, pl. 28, figs. 4a-d).

Loxoconcha sp. aff. *L. sarasotana* Benson and Coleman. MORALES, 1966, p. 71, 73, pl. 6, figs. 2a, b.

DIAGNOSIS: "A species of *Loxoconcha* distinguished by its nearly straight dorsal and ventral margins, short caudal process more noticeable in females, and evenly reticulate surface." (Morales, 1966). It is also distinguished by a spine or knob on postventral margin of males.

DESCRIPTION: Subovate, moderately, calcified, medium size. Lateral view, female, dorsal and ventral margins nearly straight and subparallel. Anterior margin is evenly rounded below mid-height, sloping and straightened above up to anterior cardinal angle. Posterior margin rounded below with an acutely rounded caudal process in females just above mid-height; above caudal process the posterior margin is straight and sloping to the posterior cardinal angle; posteroventral margin is compressed into keel-like edge. Well preserved specimens have a delicate frill-like extension at the anterior and posterior margins beyond the rim. Males differ by being longer and relatively lower; males also have slightly converging dorsal and ventral margins (toward anterior), a blunt posteroventral spine, and a less prominent caudal process.

Dorsal view: Females are subovate, tumid, anterior and posterior compressed, greatest width at middle. Males are more elongate, sides are subparallel. All specimens, left valve slightly larger than right.

Surface: Reticulate, a mesh-like network of low narrow ridges. Reticulations nearly equidimensional in central area, near margins they are elongate and parallel to nearest margin. A low narrow rim is anterior, ventral, and posterior margins. Eye tubercle, indistinct.

Internal view: Hinge, right valve, anterior element is a crescent-shaped socket with an inclosed rounded tooth; medial groove formed by two weakly crenulate ridges; a posterior crescent shaped tooth continues down as selvage. Left valve, hinge, anterior element a small round tooth, followed by a small half circular socket that is open to the inside; medial element is a weakly crenulate bar, slightly enlarged at each end; posterior crescent shaped socket with inclosed small round tooth. Above posterior socket is an enlarged continuation of the selvage. Inner lamella, moderately wide at anterior, narrow but obvious at posteroventral and posterior areas. Anterior vestibule equals about one-half width of inner lamella; marginal pore canals are few, slightly curved to straight. Selvage is narrow, prominent at anterior and posterior; high, sharp, and sinuous at ventral area. Flange of right valve is thickened to form a posteroventral blunt spine or knob. Central muscle scars, four elongate adductors in subvertical row; frontal scar "U"- or "V"-shaped.

HOLOTYPE: HVH 9495, figured specimen, male carapace, length .59 mm, height .33 mm, width .31 mm.

PARATYPES: HVH 9496, female carapace, length .51 mm, height .30 mm, width .28 mm; HVH 9497, figured specimen, female carapace, length .55 mm, height .36 mm, width .27 mm, HVH 9498, ?juvenile female, length .50 mm, height .35 mm; HVH 9499, male RV, length .54 mm, height .36 mm; HVH 9500, male LV, length .53 mm, height .35 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°57.0'N, 91°51.0'W, station 118 of this study.

DIMENSIONS: Females, carapaces, length .51-.59 mm; height .30-.37 mm; width .27-.32 mm.

MATERIAL: Adults, 60 carapaces, 337 valves; juveniles, 11 carapaces, 68 valves.

REMARKS: Morales (1966) first suggested that this form should be recognized as a separate species. The specimens in this paper are somewhat larger than those reported by Morales, but he had few specimens to examine.

Loxoconcha wilberti Puri, 1954, is similar in external shape but differs in the internal morphology. *L. wilberti* has a nearly circular posterior hinge socket in the right valve, a crescent-shaped frontal muscle scar that is open downward, and does not have a blunt spine on the posteroventral margin of the right valve. Puri (1954) stated that *L. wilberti* has a posteroventral spine, but his illustrations (Plate 10, figure 1,2) indicate that the spine is on the lateral surface. *Loxoconcha sarasotana* Benson and Coleman, 1963, differs by having a sharp ridge that is parallel to the posterior and ventral margins, a non-crescentic posterior element of the right valve hinge, and in lacking the posteroventral spine.

The shape and ornamentation of *Loxoconcha australis* Brady, 1880, distinguish that species from the one described here. *L. australis* differs by having ventral and dorsal margins that are not straight and that do not converge in the male; it also has a large eyespot and lacks a posteroventral spine.

Loxoconcha avellana Brady, 1866, was reported and illustrated by van den Bold (1966a) who included several forms from the Gulf of Mexico in synonymy. This writer cannot disagree with van den Bold's identification of the specimens from Venezuela, but does believe that the Holocene forms of Swain (1955), Puri (1960), and Curtis (1960) are not *L. avellana. L. avellana* has a convex dorsum, is punctate but not reticulate and apparently does not have a postero-ventral spine in the male, and the original specimens were larger (length of .74 mm). These characters are summarized from a copy of the original illustrations and descriptions, not any of the original specimens.

This species is named in honor of Dr. Gustavo A. Morales, who first recognized this form to be an undescribed species.

OCCURRENCE: Stations 1, 3, 4, 6, 25, 37-42, 49, 50, 52-54, 56-61, 63, 64, 66-69, 73-78, 80-85, 87, 92, 93, 100-105, 107-114, 117-120, and 122.

ECOLOGY: Water depths of 14 to 204 feet; sediments were varied from sand to sand-silt-clay to clayey silt and silty clay; foraminiferal P/B ratios of .005 to .60. Previously reported from brackish and marine waters at depths of about five to 90 feet.

Family LEPTOCYTHERIDAE Hani, 1957
Genus LEPTOCYTHERE Sars, 1925

LEPTOCYTHERE PARACASTANEA
Swain, 1955
Plate 5, figure 9

Leptocythere paracastanea SWAIN, 1955,p. 640, pl. 62, fig. 7; ?pl. 63, figs. 1a-c; ?text figs. 39:5a, b. CURTIS, 1960, p. 478, pl. 2, (top) fig. 13. DARBY, 1965, p. 20, pl. 3, figs. 1-10; pl. 4, figs. 1-9. ENGEL and SWAIN, 1967, p. 413.

Cytheromorpha paracastanea (Swain). MORALES, 1966, p. 66, pl. 6, fig. 20.

DIMENSIONS: ?Female carapace, length .47 mm; height .25 mm; width .20 mm.

REMARKS: Only one adult specimen was undamaged and measurable. Darby (1965) conclusively demonstrated that this species should be assigned to the genus *Leptocythere* Hanai. Morales (1966) suggested that the specimens described by Swain (1955) may represent two species. As with Morales' specimens, those in this study are similar to the ?female on Plate 62, figure 7, of Swain (1955). The specimens collected and reported here are smaller than the holotype, a ?male, but similar in size and other features to the ?female paratype.

OCCURRENCE: Stations 1, 7, 58, 59, 61, 64, 69, 74, 75, 78, 80, 82, 85, 92, 96, 97, and 11.

ECOLOGY: Water depths of 48 to 204 feet; clayey silts and silty clays; foraminiferal P/B ratios of .01 to .60. Previously report-

PLATE 3

Figure Page

1. *Cytherura sandbergi* Morales, HVH 9455, right valve (100X) 63
2. *Cytherura swaini* van den Bold, HVH 9456, left valve (200X) 63
3. *Krithe* cf. *K. producta* Brady , HVH 9457, left valve (100X) 60
4. *Cushmanidea* sp., HVH 9458, left valve (100X) 62
5. *Parakrithella* sp., HVH 9459, right valve (100X) 61
6. *Neocytherideis* cf. *N. cylindrica* (Brady), HVH 9460, right valve (100X) 61
7. *Cytherura* sp. A, HVH 9461, right valve (100X) 63
8. *Cytherura* sp. B, HVH 9462, right valve (100X) 63
9. *Cytheropteron hamatum* Sars, HVH 9463, left valve (100X) 64
10-11. *Cytheropteron morgani* Kontrovitz, n. sp. 65
10. Paratype, HVH 9473, right valve (100X)
11. Holotype, HVH 9471, left valve (100X)

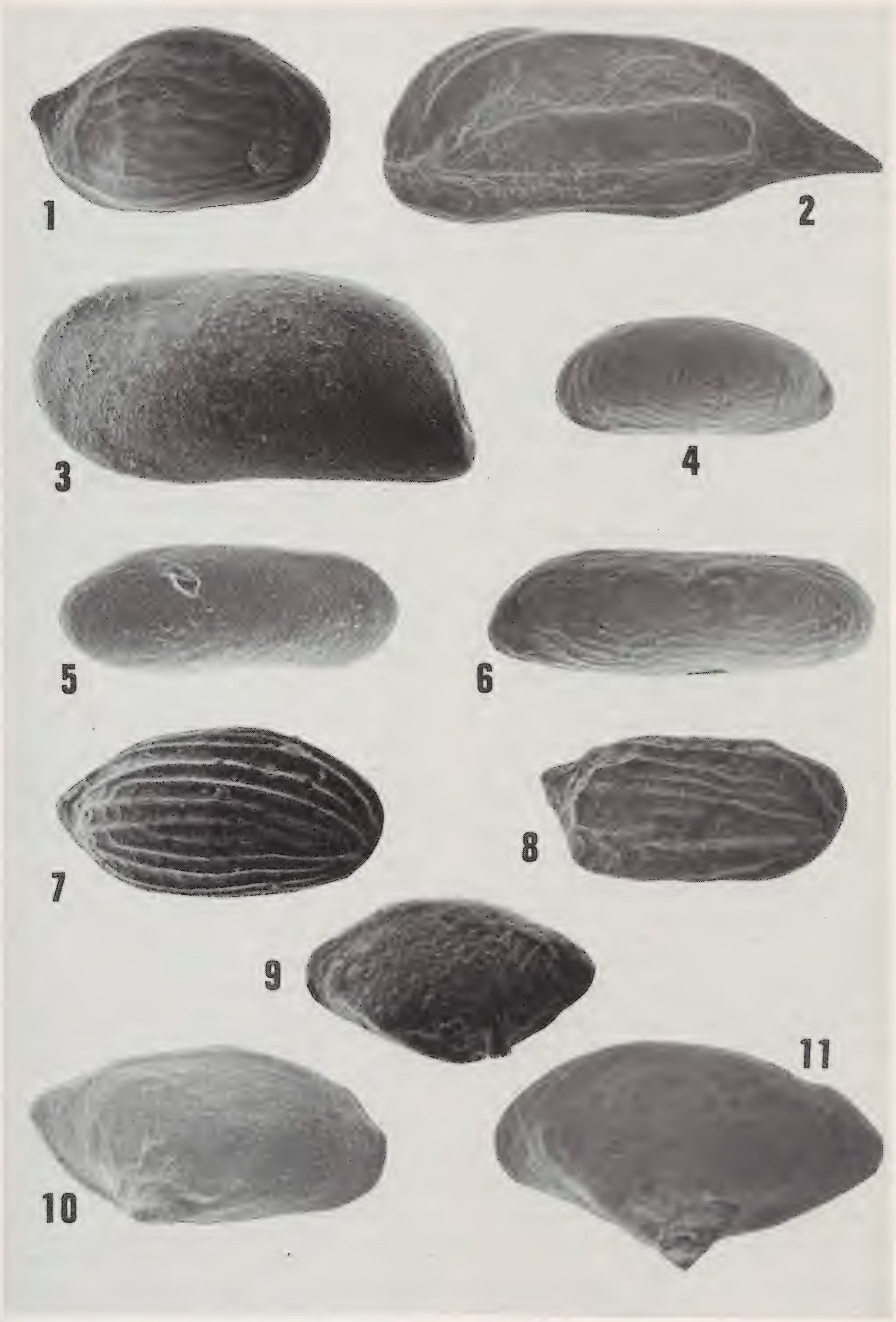

PLATE 3

ed from brackish and marine waters from depths of five to 500 feet.

Family PARADOXOSTOMATIDAE
Brady and Norman, 1889
Subfamily PARADOXOSTOMATINAE
Brady and Norman, 1889
Genus PARADOXOSTOMA Fischer, 1855

PARADOXOSTOMA ENSIFORME
Brady, 1868
Plate 5, figure 10

Paradoxostoma ensiforme BRADY, 1867, p. 198. BRADY, 1868, p. 460, pl. 35, figs. 8-11. BRADY, 1880, p. 150, pl. 35, figs. 3a-d. SARS, 1928, p. 258, pl. 67, fig. 1. ENGEL and SWAIN, 1967, p. 418, pl. 2, fig. 18.
Paracytherois ensiforme (Brady). PURI, 1960, p. 119.
Paracytherois ensiformis (Brady). CURTIS, 1960, p. 478, pl. 1, fig. 29.

DIMENSIONS: Right valve length .78 mm; height .32 mm.

REMARKS: Curtis (1960) illustrated a specimen that is identical to the juveniles found in this study.

OCCURRENCE: Stations 4, 6, 7, 9, 39-41, 43, 63, 64, 75, 103, and 113.

ECOLOGY: Water depths of 84 to 204 feet; clayey silt and sand-silt-clay; foraminiferal P/B ratios of .01 to .17. Previously reported from depths of less than 70 feet in both brackish and marine salinities (Brady, 1880; Swain, 1955; Puri, 1960). Curtis (1960) encountered this species at depths of greater than 90 feet east of the Mississippi River Delta. In Curtis's study and in this paper, the apparent extended depth-ranges of this species, and some others, may be caused by the availability of samples from deeper water than any previously examined.

Genus MACHAERINA
Brady and Norman, 1899

MACHAERINA cf. M. TENUISSIMA
(Norman, 1869)
Plate 5, figure 8

?*Bythocythere tenuissima* NORMAN, 1869, p. 294.
Machaerina tenuissima (Norman). CURTIS, 1960, p. 478, pl. 1, fig. 27.
?*Xiphichilus tenuissimoides* SWAIN, 1967, p. 98, 99, pl. 2, fig. 11; pl. 9, figs. 14a-c. SWAIN and GILBY, 1967, p. 331, pl. 32, fig. 6; pl. 34, fig. 12.

DIMENSIONS: Right valve, length .92 mm; height .21 mm.

REMARKS: Swain (1967) described a new species from the Gulf of California using size to differentiate that form from *M. tenuissima* (Norman). Specimens from the Louisiana coast are larger than Swain's examples and smaller than Norman's material. It should be noted that the dimensions given by Swain (1967) for his species are incorrect; from his Plate 9, Figure 14a, it is evident that the length is about .72 mm and height .25 mm (not length .72 mm and height .88 mm).

OCCURRENCE: Stations 29, 68 and 72.

ECOLOGY: Water depths of 99 to 306 feet; silty clays and clayey silts; foraminiferal P/B ratios of .125 to .17. Previously reported from brackish and marine conditions in water as deep as 126 feet by Swain and Gilby (1967) and at depths greater than 90 feet by Curtis (1960).

Genus LUVULA Coryell and Fields, 1937

REMARKS: This genus has been placed in synonymy with *Jonesia* Brady, 1866 (see Kesling, 1961, page Q268). Van den Bold (1963, 1966a, 1967b) regarded *Luvula* as a valid genus and he is followed here.

LUVULA GIGARTONOIDES
Kontrovitz, n. sp.
Plate 5, figures 5, 6

DIAGNOSIS: Distinguished by its greatest height at the posterior cardinal angle, right valve higher than the left at mid-length, acutely rounded posterior, and horizontal "U"-shaped anterior hinge element in the right valve.

DESCRIPTION: Elongate, ovate, lightly calcified, small. Dorsal margin is nearly straight from anterior cardinal angle to posterior cardinal angle, acutely rounded at posterior cardinal angle. Ventral margin is slightly sinuate with a weak concavity in front of mid-length. Anterior margin is evenly rounded; posterior margin, slightly convex from posterior cardinal angle to below mid-height, acutely rounded below mid-height at greatest length. Right valve higher than left at mid-length; left valve slightly overlapping at anteroventral margin. Surface is smooth, shiny on translucent specimens.

Dorsal view: Greatest width is just behind mid-length, evenly convex to anterior and posterior. Anterior margin acutely rounded, posterior more broadly rounded but also acute.

Sexual dimorphism: A few specimens that are lower at the posterior cardinal angle were found. These may represent males of this species (see remarks below).

Internal view: Hinge, right valve, anterior element is positive and "U"-shaped, with the closed portion forward; a medial bar is very thin and extends to the area beyond the posterior cardinal area. The selvage at the posterior margin is heavy and expanded below cardinal angle into a "Y"-shaped socket. There is a distinct groove that extends above the medial bar. (The dentition of the right valve is similar to that of *Luvula palmerae* Coryell and Fields, 1937, as described by van den Bold, 1967b; see remarks below). Left valve, a bar is greatly expanded anteriorly into an elongate element and posteriorly into a rounded element that seem to fit into the "U"-shaped and "Y"-shaped terminal portions of the right valve hinge. Marginal area, wide at anterior and posteroventral regions; very narrow at oral area. Anterior vestibule is large and not constricted dorsally or ventrally; line of concrescence in the vestibule is non-serrate, that is, nearly smooth; in the posteroventral area, line of concrescence is well removed from the inner margin. A small posterior vestibule has a slightly serrate line of concrescence. Radial pore canals, few, straight, and rarely bifurcating. Central muscle scars composed of a subvertical row of four elongate scars; frontal scar is variable, but usually vertically elongate.

HOLOTYPE: HVH 9504, figured specimen, ?female carapace, length .48 mm, height .26 mm, width, specimen is damaged.

PARATYPES: HVH 9505, ?female right valve, length .46 mm, height .25 mm; HVH 9506, figured specimen, ?male carapace, length .48 mm, height .23 mm, width .19 mm; HVH 9507, ?male LV, length .46 mm, height .23 mm; HVH 9508, ?female LV, length .44 mm, height .23 mm; HVH 9509, ?female RV, length .48 mm, height .26 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°52.8'N, 89°12.6'W, station 14 of this study.

DIMENSIONS: ?Females, length .46-.51 mm; height .25-.26 mm; width .18-.21 mm.

MATERIAL: Adults, 10 carapaces, 24 valves; juveniles, five carapaces, five valves.

REMARKS: A few specimens tentatively placed in this species may be males; the ?males are lower at the posterior cardinal angle and have more fragile hinges than the ?females. Van den Bold (1960) noted a similar possible dimorphism in *Luvula gigarton; Luvula gigarton* differs from this species in the hinge by having "a short groove which widens at each end" in the right valve and by having a dorsal and ventral constriction of the anterior vestibule. *Luvula palmerae* Coryell and Fields, 1937, differs by having a pointed posterior in lateral view and a more complex group of central muscle scars.

In summary, *Luvula* sp. has the external lateral outline of *L. gigarton* and the hingement of *L. palmerae.* All characters, considered together, clearly distinguish the three species.

This species is named for its similarity to *Luvula gigarton.*

OCCURRENCE: Stations 3, 7, 9, 14, 20, 25, 38, 40, 41, 46, 64, 75, 85, 104, 105, 111, 113, 115, 118, and 119.

ECOLOGY: Water depths of 54 to 420 feet; clayey silts and sand-silt-clay; foraminiferal P/B ratios of .005 to .26.

LUVULA? sp.
Plate 5, figure 7

DIAGNOSIS: Distinguished by its rounded posterodorsal outline, large elongate, rounded anterior hinge element (right valve), pointed posterior margin, and elongate compressed area at posteroventral postion of each valve.

DESCRIPTION: Carapace somewhat bairdioid, lightly calcified, small. Dorsal margin is slightly convex to posterodorsal area where outline is broadly convex; ventral margin sinuate with broad shallow convexity in front of and at mid-length. Anterior margin evenly rounded; posterior margin slightly convex from posterior cardinal angle to below mid-height where greatest length exists. Greatest length is at a pointed caudal process-like extension; below greatest length, posterior is broadly convex. Right valve is slightly higher than left from anterior to posterior cardinal angles; left valve overlaps right at posteroventral area. Surface is generally smooth, with an elongate shallow depression at posteroventral surface of each valve. A long narrow rim is at anterior from about mid-height to bottom of anterior margin. (visible only at about 150 magnifications or higher).

Internal view: Hinge, right valve, anterior element is an elongate rounded tooth, connected above to a medial bar by a thin loop (closed portion forward); loop forms a shallow socket. Medial bar is thin but high and lies above a shallow groove that is closed to posterior. Raised thin edge of selvage extends up from posterior and is expanded, forming a "V"-shaped socket with the medial bar. Left valve, a medial bar is expanded at each end; anterior is high and blade-like; posterior is small and rounded. There is a weak socket beyond each end of the medial bar, a low shelf extends below the bar. Inner lamella is wide; widest at anterior. Inner margin, evenly curved at anterior but sinuate at posteroventral area. Line of con-

crescence is far removed from inner margin at anterior and posteroventral areas. Marginal pore canals are few, apparently simple, slightly curved anterodorsally, and a few are false. Central muscle scars, composed of a compact subvertical, curved row of four, top and bottom scars are oval; middle scars are elongate. Frontal scar is large and round; two small mandibular scars are below and anterior to adductors.

DIMENSIONS: Right valve, length .47 mm; height .23 mm; (see remarks below).

MATERIAL: One carapace, nine valves.

REMARKS: The single carapace has become disarticulated, therefore, the measurement of width cannot be given. This species is tentatively classified in the genus *Luvula* because the anterior hinge element of the right valve and the shape of the frontal muscle scar are somewhat different than in the type species *L. palmerae* Coryell and Fields, 1937. Van den Bold, 1967b, redescribed *L. palmerae* and presented a description (of internal features) used here. The lower portion of the frontal hinge element of the right valve of *L. palmerae* is not as heavy as in the species described here; the frontal scar of *L. palmerae* is irregular in shape (van den Bold, 1967b).

Luvula gigarton van den Bold, 1966a, is not pointed at the posterior and also differs in dentition and muscle scar pattern.

Subfamily CYTHEROMATINAE Elofson, 1939

Genus PELLUCISTOMA Coryell and Fields, 1937

PELLUCISTOMA MAGNIVENTRA Edwards, 1944 Plate 6, figure 5

Pellucistoma magniventra EDWARDS, 1944, p. 528, pl. 89, figs. 33-35. VAN DEN BOLD, 1950, p. 86. PURI, 1954, p. 289, pl. 15, fig. 8; text fig. 12a. PURI and HULINGS, 1957, p. 187, fig. 11:6. VAN DEN BOLD, 1957, p. 246. PURI, 1960, p. 119, pl. 2, figs. 10, 11; text figs. 8, 9. BENSON and COLEMAN, 1963, p. 41, 42, pl. 6, fig. 11; text fig. 26. HALL, 1965, p. 48, pl. 17, figs. 9-15. MORALES, 1966, p. 77, pl. 7, figs. 4a-d. GROSSMAN, 1967, pl. 14, fig. 5; pl. 20, figs. 1, 3. HULINGS, 1967, p. 651, fig. 6m. Not *Pellucistoma magniventra* Edwards. VAN DEN BOLD, 1963, p. 404, pl. 10, fig. 6.

?*Pellucistoma* aff. P. *howei* Coryell and Fields. CURTIS, 1960, p. 478, pl. 2, (top) fig. 3, (bottom) fig. 10. (Not *Pellucistoma howei* Coryell and Fields, 1937, p. 17, figs. 19a-c).

Paradoxostoma ensiforme Brady. SWAIN, 1955, p. 633, pl. 63, fig. 7. (Not *Paradoxostoma ensiforme* Brady, 1867, p. 198).

DIMENSIONS: Carapaces (two), length .61-.64 mm; height .31-.33 mm; width .22-.26 mm.

REMARKS: Based on this study and previous reports of this form, it is evident that *Pellucistoma magniventra* shows much intraspecific variation. The convexity of the posteroventral area is variable, especially in juveniles; apparently the convexity increases and the length/height ratio decreases with

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PLATE 4

Figure Page

1-2. *Cytheropteron tumulosimilis* Kontrovitz, n. sp. 68
1. Paratype, HVH 9477, left valve (200X)
2. Holotype, HVH 9476, right valve (200X)

3. *Paracytheridea* sp., HVH 9464, right valve, ?juvenile (200X) 68

4. *Hemicytherura* cf. *H. sablensis* Benson and Coleman, HVH 9465, right valve (100X) 93

5. *Puriana rugipunctata* (Ulrich and Bassler), HVH 9466, right valve (100X) 69

6. *Aurila floridana* Benson and Coleman, HVH 9467, right valve (100X) 69

7-8. *Basslerites vokesi* Kontrovitz, n. sp. 89
7. Paratype, HVH 9482, carapace, male, left view (100X)
8. Holotype, HVH 9481, left valve, female (100X)

9-10. *Puriana krutaki* Kontrovitz, n. sp. 70
9. Holotype, HVH 9487, carapace, dorsal view (100X)
10. Paratype, HVH 9489, left valve (100X)

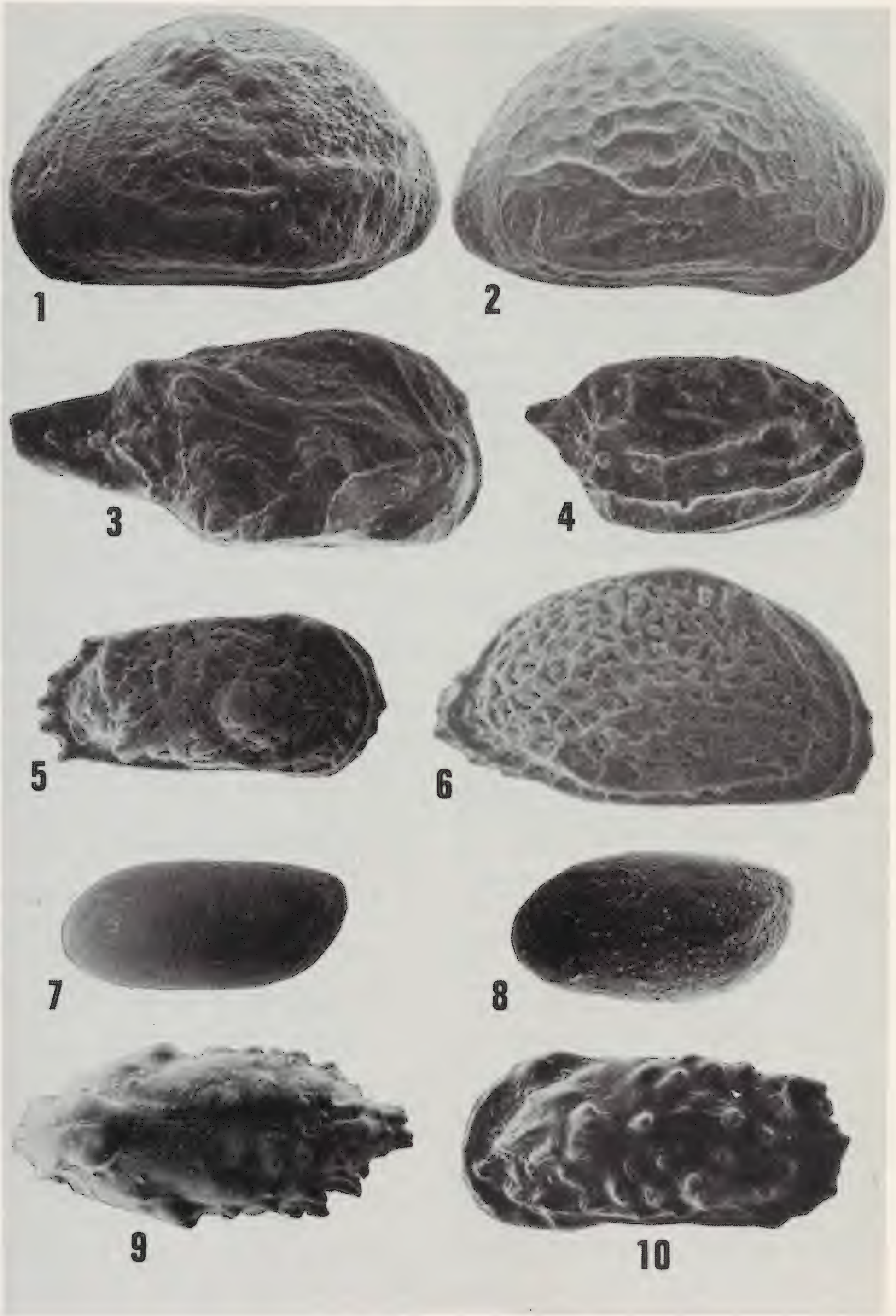

PLATE 4

maturity. The adult specimens in this study are similar in lateral outline to those illustrated by Benson and Coleman (1963), but the juveniles are closer to a paratype illustrated by Edwards (1944, Plate 88, figure 35). The variety of adults is such that there are insufficient differences to separate the form from *P. magniventra.*

OCCURRENCE: Stations 3-5, 7, 9, 50, 58, 70, 74-76, 106, 113, 118, 121, and 123.

ECOLOGY: Water depths of 20 to 186 feet; sediments varied from sand-silt-clay to silty clay and clayey silt; foraminiferal P/B ratios of .01 to .13. Salinities were brackish at two stations and marine at the remaining seventeen collection locations. Previously reported from five feet or less to 550 feet; salinities were brackish to marine.

Family PECTOCYTHERIDAE Hanai, 1957
Genus MUNSEYELLA van den Bold, 1957

MUNSEYELLA BERMUDEZI van den Bold LOUISIANENSIS Kontrovitz, n. subsp.
Plate 6, figures 3, 4

DIAGNOSIS: Distinguished from *Munseyella bermudezi* by a blunt spine on a horizontal ridge at the posterior cardinal angle, prominence of the horizontal ornamentation, two prominent vertical ridges in the dorsomedial area, and its small size.

DESCRIPTION: Carapace subtriangular, moderately calcified, small. In lateral view, dorsal margin slightly convex, ventral margin nearly straight, with slight concavity in front of mid-length, strongly converging toward posterior. Anterior margin evenly rounded, spinose; posterior, truncate with two blunt spines.

Dorsal view: Greatest width at posterior one-third, ends compressed.

Surface has ridges and intervening pits. Anterior rim strong upper area, weaker near ventral margin; dorsal ridge, changes to vertical direction in front of posterior cardinal angle and ending just below mid-height on lateral surface. There are two nearly horizontal ridges connected by weaker but distinct ridges; the upper horizontal ridge starts just in front of posterior vertical ridges and ends at mid-length; lower horizontal ridge is connected to venter by a downward sloping extension, forming an indistinct "V" with apex toward rear. Small ridges cross limbs of "V". A blunt spine is seen above bend in dorsal ridge. Sexual dimorphism, males are relatively lower.

Internal view: Hinge, right valve, anterior element is a small pointed tooth, followed by a large socket; medial crenulate groove; large posterior socket and large oval posterior tooth oriented vertically. Left valve and anterior socket, small tooth, crenulate bar, large tooth, small socket; in the left valve, sockets open to interior. Marginal areas, anterior and posterior wide; anterior vestibule wide, posterior distinct and widest at posteroventral area. Marginal pore canals are evenly spaced, very short and simple, most correspond to marginal spines. Muscle scars are obscured.

HOLOTYPE: HVH 9516, figured specimen, carapace, length .31 mm, height .18 mm, width .13 mm.

PARATYPES: HVH 9517, figured specimen, carapace, length .30 mm, height .18 mm, width .13 mm; HVH 9518, carapace, length .30 mm, height .18 mm, width .14 mm; HVH 9519, carapace, length .31 mm, height .18 mm, width .14 mm; HVH 9520, carapace, length .31 mm, height .19 mm, width .17 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°48.0'N, 89°21.8'W, station 28 of this study.

DIMENSIONS: Females, carapaces, length .30-.32 mm; height .18-.19 mm; width .13-.17 mm; male (one carapace), length .30 mm; height .15 mm; width .13 mm.

MATERIAL: Sixteen carapaces, four valves.

REMARKS: This subspecies differs from *Munseyella bermudezi bermudezi* van den Bold, 1966a, as indicated in the diagnosis above. Both subspecies are somewhat similar to *M. atlantica* Hazel and Valentine, 1969, but differ by having more converging dorsal and ventral margins. *M. bermudezi bermudezi* also differs from *M. atlantica* by lacking a posterodorsal spine, its smaller size, and more subdued ornamentation with no prominent vertical ridges in the dorsomedial area. *M. bermudezi louisianensis,* reported here, differs from *M. atlantica* by having distinct vertical cross ridges in the ventral "V"-shaped ornamentation, in being much smaller, and by having a prominent horizontal ridge in the dorsomedial area.

OCCURRENCE: Stations 7, 9, 28, 68, 69, 86-89, 93, and 94.

ECOLOGY: Water depths of 198 to 306 feet; mostly in silty clay with a few valves in sand-silt-clay; foraminiferal P/B ratios of .07 to .42.

MUNSEYELLA sp.
Plate 6, figure 8

DIAGNOSIS: Distinguished by the large down turned extension of the dorsal ridge at the posterior cardinal angle, two prominent subvertical ridges in the medial and posteromedial areas, and a blunt spine at the posterior cardinal angle.

DESCRIPTION: Trapezoidal, moderately calcified, small. Dorsal margin is straight; ventral margin

slightly convex converging posteriorly. Greatest height at anterior cardinal angle. Anterior margin is evenly rounded below mid-height, more obliquely rounded above. (The specimens recovered have the remnants of spines at the anterior). Posterior margin is obliquely rounded with two blunt spines, one just above mid-height, other below.

Dorsal view: Elongate, spatulate, greatest width at middle. Anterior compressed, posterodorsal ridges form a "V", with apex forward to about middle. Spines at posterior cardinal angles prominent, knob-like. Left valve slightly larger than right.

Surface, has ridges and intervening pits; narrow anterior rim continues as a dorsal ridge (or rim) that widens at posterior cardinal angle terminating just below mid-length. A vertical ridge is located in front of downward flexure of dorsal ridge; another vertical ridge at about mid-length; neither vertical ridge touches dorsal ridge. Anterior lateral surface with several connected, low, curved ridges. Interior features not seen, except a few anterior radial pore canals that correspond in position to the remnants of marginal spines.

DIMENSIONS: Carapace, length .32 mm; height .20 mm; width .14 mm.

REMARKS: This species differs from *Munseyella atlantica* Hazel and Valentine, *M. bermudezi bermudezi* and *M. bermudezi louisianensis* (of this report) by the presence of prominent vertical ridges.

OCCURRENCE: Stations 20 and 91.

ECOLOGY: Water depths of 198 and 420 feet; silty clays; foraminiferal P/B ratios of .26 and .41.

Framily TRACHYLEBERIDIDAE
Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE
Sylvester-Bradley, 1948
Genus ACTINOCYTHEREIS Puri, 1953

ACTINOCYTHEREIS GOMILLIONENSIS
(Howe and Ellis, 1935)
Plate 6, figure 6

Cythereis exanthemata var. *gomillionensis* HOWE and ELLIS, 1935, p. 19, pl. 1, figs. 6-12; pl. 4, fig. 3. EDWARDS, 1944, p. 521, 522, pl. 87, figs. 31, 32. VAN DEN BOLD, 1946, p. 88, pl. 10, fig. 2.

Trachyleberis exanthemata gomillionensis (Howe and Ellis). MALKIN, 1953, p. 792, pl. 81, figs. 15, 17, 18.

Actinocythereis exanthemata gomillionensis (Howe and Ellis). PURI, 1953, p. 173, 180, pl. 2, figs. 4-8; text figs. e, f. PURI, 1954, p. 253, pl. 13, figs. 16, 17. MCLEAN, 1957, p. 83, pl. 10, figs. 2a-d. HALL, 1965, p. 33, pl. 7, figs. 12-17. MCLEAN, 1966, p. 66, pl. 20, fig. 6, pl. 21, fig. 1.

Actinocythereis gomillionensis (Howe and Ellis). WILLIAMS, 1966, p. 30, figs. 18:6a-c; text figs. 24a-c.

DIMENSIONS: Carapaces, female, length .79 mm; height .42 mm; width .42 mm; male, length .82 mm; height .42 mm; width .41 mm.

REMARKS: Williams (1966) believed this form should be distinguished as a species. He stated that it "is easily recognized by its row of fine pustules above dorsal row of spines and adjacent to hinge of right valve." Specimens in the current study show that character but do not have a "smooth ridge" extending from the eye tubercle parallel to the anterior margin, as described by Williams (1966).

The specimens examined here are variable, with some smooth and others spinose just behind the anterior margin. In addition, well preserved specimens show some branching of the spines near the dorsum, whereas worn individuals retain only blunt spines.

Actinocythereis triangularis Morales, 1966, is differentiated from *A. gomillionensis* by the latter's "larger size, subquadrate outline and stronger ornamentation." Unfortunately, Morales' illustrations indicate that the specimens in that study have been somewhat eroded on their surfaces just as Morales suggested for *A. subquadrata* Puri, 1960.

Cythere bahamenis Brady, 1870, differs from this species by being less spinose than even the most worn specimens of the current study, in not having three distinct rows of lateral spines, and in being smaller (.50 mm).

OCCURRENCE: Station 1, 4, 7, 37, 41, 43, 50, 56, 63, 74, 78, 83, 86, 88, 102, 105, 107, 109-111, 113, 115, and 117-119.

ECOLOGY: Water depths of 54 to 192 feet; sediments varied from clayey silt to silty clay and sand-silt-clay; foraminiferal P/B ratios .01 to .26. Previously reported from shallow depths with marine salinities.

ACTINOCYTHEREIS VANDENBOLDI
Kontrovitz, n. sp.
Plate 6, figures 1, 2

DIAGNOSIS: Distinguished by its highly compressed anterior and posterior, long curved antero-

ventral and posteroventral denticles, median row of spines that bifurcates anteriorly forming a "Y"-shaped ornamentation, and in internal view the acutely rounded, nearly pointed, posterior of the right valve.

DESCRIPTION: Subtrapezoidal, sloping toward posterior, heavily calcified, medium size. Dorsum nearly straight as is ventral margin, but latter has slight convexity behind mid-length, converging. Anterior margin is broadly rounded below mid-height, acutely rounded above and denticulate; posterior margin acutely rounded below mid-height with a straight outline from greatest length to posterior cardinal angle. Greatest length is below mid-height.

Surface: Heavy spines in rows, prominent, anterior rim, marginal denticles. Denticles are long, delicate, and curved. Lateral spines are in rows, becoming blade-like on ventral and dorsal margins; some bifurcate at posterodorsal area; one lateral row of spines extends from one-third of length behind anterior and down to near ventral margin; center row forms a "Y" with the open end forward; subdorsal row has some blade-like and bifurcating spines; dorsal row is deflected downward at posterior cardinal angle and often reaches the central row. A large eye tubercle is at anterior cardinal angle. Some specimens also have a distinctly spinose posteroventral margin.

Sexual dimorphism: Males are lower, therefore they appear to be longer than females.

Internal view: Hinge, right-valve, anterior tooth is high and rounded and becomes curved, forming the lower rim of a circular socket; narrow median groove is shallow; posterior tooth is large, low, rounded. Hinge, left valve, anterior socket is indistinct and open to front; behind socket is a long low tooth that merges with a low bar; bar is expanded at posterior and is followed by a circular socket that opens inward. Inner lamella is wide at posterior and anterior but narrow at anteroventral area. Line of concrescence coincides with inner margin. Selvage is peripheral and low. Some specimens have low concentric striae on inner lamella at anterior. Marginal pore canals are numerous, clustered, sinuate, and most pass through denticles. Muscle scars are obscured by ornamentation.

HOLOTYPE: HVH 9510, figured specimen, carapace, length .78 mm, height .45 mm, width .40 mm.

PARATYPES: HVH 9511, figured specimen, RV, length .73 mm, height .40 mm; HVH 9512, LV, length .72 mm, height .41 mm; HVH 9513, RV, length .78 mm, height .39 mm; HVH 9514, LV, length .79 mm, height .44 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°19.2'N, 92°23.4'W, station 92 of this study.

DIMENSIONS: Carapaces, female length .78 mm; height .45 mm; width .40 mm; male, length .78 mm; height .42 mm; width .40 mm.

MATERIAL: Three carapaces, 29 valves.

REMARKS: The ornamentation is variable on the specimens examined here. Although well preserved specimens are distinct from other species, poorly preserved specimens resemble forms mentioned below:

Actinocythereis davidwhitei (Stadnichenko, 1927) is similar in size and shape to worn specimens of the current study; *A. davidwhitei* (Stadnichenko) of Puri, 1953a, is more similar to this material than those of the original description (note that Plate 39, figure 24, in Stadnichenko, 1927, is inverted).

Pooser (1965) considered *A. gibsonensis* (Howe and Chambers, 1935), and *A. davidwhitei* to be conspecific. The specimens used to describe *A. gibsonensis* are not as highly

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PLATE 5

Figure Page

1. *Loxoconcha* cf. *L. matagordensis* Swain, HVH 9468, left valve (100X) 72
2. *Loxoconcha* cf. *L. purisubrhomboidea* Edwards, HVH 9469, left valve (100X) 72
3-4. *Loxoconcha moralesi* Kontrovitz, n. sp. 72
   3. Holotype, HVH 9495, carapace, male, right view (100X)
   4. Paratype, HVH 9497, carapace, female, right view (100X)
5-6. *Luvula gigartonoides* Kontrovitz, n. sp. 76
   5. Holotype, HVH 9504, carapace, damaged, left view (100X)
   6. Paratype, HVH 9506, carapace, right view (100X)
7. *Luvula*? sp., HVH 9470, right valve (100X) 77
8. *Machaerina* cf. *M. tenuissima* (Norman), HVH 9485, left valve (100X) 76
9. *Leptocythere paracastanea* Swain , HVH 9486, left valve (100X) 74
10. *Paradoxostoma ensiforme* Brady , HVH 9493, right valve (100X) 76

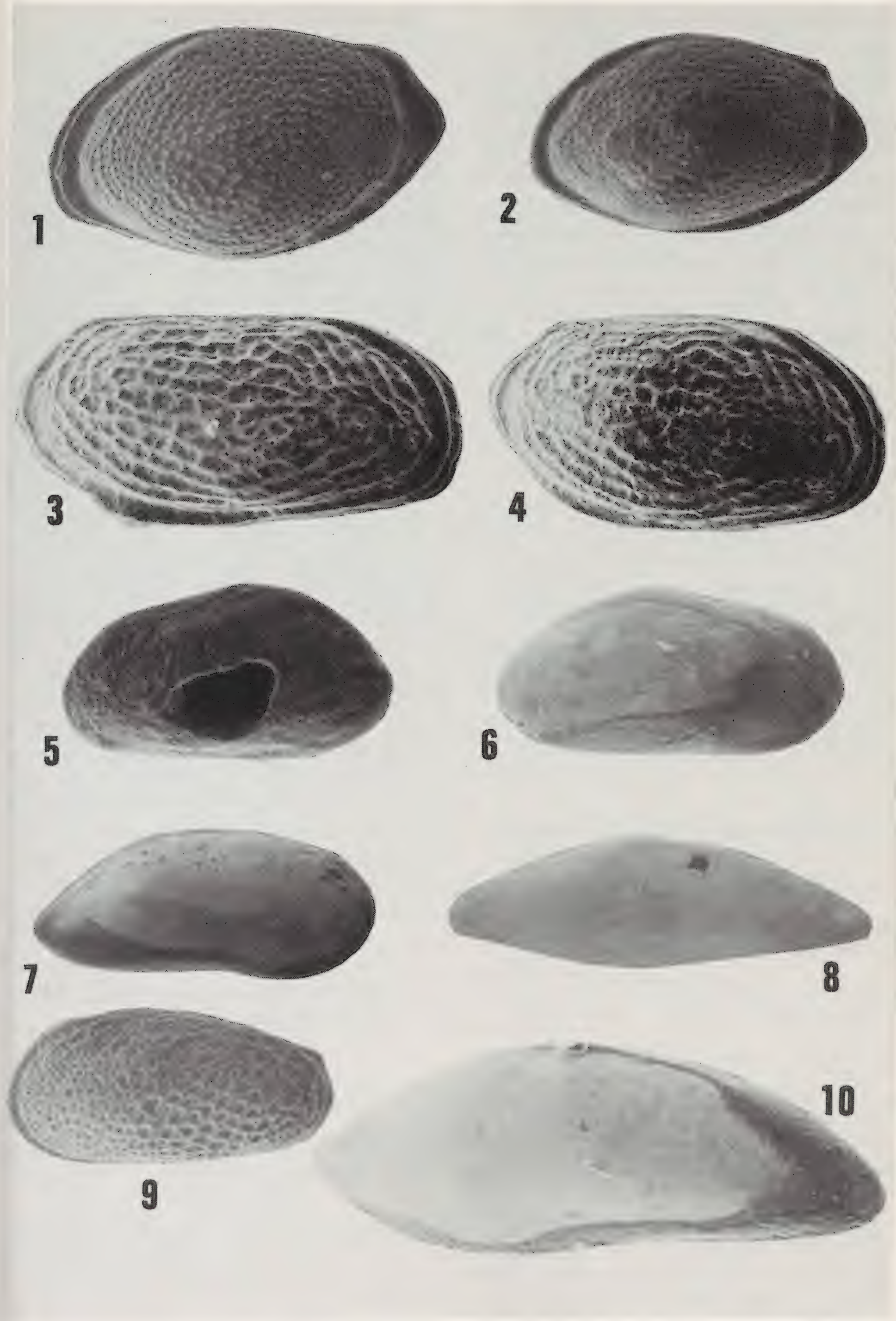


PLATE 5

ornamented as those reported in the current study.

This species is named in honor of Dr. W. A. van den Bold for his kind suggestions and criticism that greatly improved this study.

OCCURRENCE: Stations 69, 89, 91-93, and 118.

ECOLOGY: Water depths of 60 to 205 feet, with all but two valves from depths greater than 186 feet and in silty clays; foraminiferal P/B ratios of .01 to .60.

Subfamily BUNTONIINAE Apostlescu, 1961

Genus BUNTONIA Howe, 1935

BUNTONIA? sp.

Plate 6, figure 7

MATERIAL: One damaged valve.

REMARKS: This species is represented by a single damaged valve; it is recorded and illustrated to allow comparison in future studies. Curtis (1960) reported a species of *Butonia* east of the Mississippi River Delta, but a comparison cannot be carried out unless more specimens are available.

OCCURRENCE: Station 64.

ECOLOGY: Water depth of 69 feet; clayey silt; foraminiferal P/B ratio of .05.

Subfamily ECHINOCYTHEREIDINAE Hazel, 1967

Genus ECHINOCYTHEREIS Puri, 1953

ECHINOCYTHEREIS MARGARITIFERA (Brady, 1870)

Plate 7, figure 1

Cythere margaritifera BRADY, 1870, p. 192, pl. 27, figs. 3, 4.

Cythereis garretti HOWE and MCGUIRT, 1935, p. 20, pl. 3, figs. 17-19; pl. 4, figs. 5, 15.

Buntonia? sp. cf. B. ?*garretti* (Howe and McGuirt). SWAIN, 1951, p. 39, pl. 3, fig. 6; pl. 4, figs. 4-6.

Echinocythereis garretti (Howe and McGuirt). PURI, 1954, p. 260, pl. 12, figs. 2-5; text figs. 9a, b. BROWN, 1958, p. 65, pl. 6, fig. 12. BENSON and COLEMAN, 1963, p. 46, pl. 4, figs. 4, 5; text fig. 30. HALL, 1965, p. 34, pl. 8, figs. 15, 16, 18-23. HULINGS, 1967, p. 653, fig. 6q. SWAIN, 1968, p. 15, pl. 4, fig. 12; text fig. 13.

Echinocythereis margaritifera (Brady). CURTIS, 1960, p. 478, pl. 1, fig. 19. HAZEL, 1967, p. 36, 37, pl. 6, figs. 6, 7, 9.

DIMENSIONS: Carapace, female, length .85 mm; height .52 mm; width .49 mm; left valve, females, length .72-.85 mm; height .47-.54 mm.

REMARKS: This species shows much variation of the ornamentation. Well preserved specimens have long spines that are delicate at the distal ends; poorly preserved specimens retain only blunt knob-like projections. Spines near the dorsal margin may bifurcate, but that feature is not seen on poorly preserved specimens.

Benson and Coleman (1963) have used the arrangement of spines to differentiate several species of *Echinocythereis,* but as with individual spines, the pattern of all spines is variable from apparent randomness to alignment in rows. All such arrangements were observed by this writer on specimens of *E. margaritifera.*

It should be noted that in *E. margaritifera,* sexual dimorphism is not well expressed in length/height ratios because the eye tubercle is high in both sexes. The males are, however, much lower in the posterior portion of the carapace.

OCCURRENCE: Stations 4, 5, 7, 9, 17, 20, 29, 31, 43, 44, 50, 59, 62-64, 67-76, 81, 83, 84, 86-89, 91-93, 95-110, 112, and 117.

ECOLOGY: Water depths of 42 to 788 feet with over 98% of the valves from less than 225 feet; clayey silts and silty clays; foraminiferal P/B ratios of .01 to .60. Previously reported from the area east of the Mississippi River Delta, deeper than 90 feet, and in the Atlantic Ocean from 270 to 460 feet. Near southwestern Florida, this species has been identified only from water depths greater than 60 feet.

Genus HENRYHOWELLA Puri, 1957

HENRYHOWELLA ex. gr. ASPERRIMA (Reuss, 1850)

Plate 7, figure 3

Henryhowella asperrima (Reuss). VAN DEN BOLD, 1957, p. 242, 243. VAN DEN BOLD, 1960, p. 169, pl. 4, fig. 10; pl. 8, fig. 2.

Henryhowella evax (Ulrich and Bassler). POOSER, 1965, p. 59, pl. 19, fig. 1; pl. 20, figs. 2, 7, 9-13.

Henryhowella ex. gr. *asperrima* (Reuss). VAN DEN BOLD, 1966b, p. 169, pl. 2, fig. 9.

DIMENSIONS: Carapaces, females, length .64-.66 mm; height .39-.42; width .39-.40; males, length .64-.70 mm; height .73-.40 mm; width .34-.35 mm.

REMARKS: Van den Bold is followed here because of his familiarity with the European material. Pooser (1965) noted van den Bold's work but retained *H. evax* as a valid name; the present writer agrees with Pooser (1965, p. 59) that *H. echinata* Puri, 1956, and *H. evax* are conspecific. The current study confirms that the ornamentation of this species is variable. Well preserved specimens have closely custered spines whereas poorly preserved examples retain only the three horizontal ridges on the posterior part of the valve. All transitional states of preservation were also observed in the material collected for this study.

The specimens examined from the Louisiana coastal area are smaller than those of Ulrich and Bassler (1904), Puri (1956), and van den Bold (1957, 1960). All other characters are identical and size alone may be the function of the environmental factors.

OCCURRENCE: Stations 68-70, and 86-97.

ECOLOGY: Water depths of 138 to 204 feet, with 99% of all valves from 150 to 204 feet; silty clay; foraminiferal P/B ratios of .13 to .60.

Subfamily PTERYGOCYTHEREIDINAE Puri, 1957
Genus PTERYGOCYTHEREIS Blake, 1933

PTERYGOCYTHEREIS MIOCENICA van den Bold, 1967
Plate 7, figure 2

Pterygocythereis sp. aff. *P. americana* (Ulrich and Bassler). BENSON and COLEMAN (part), 1963, p. 22, 23, pl. 5, figs. 2, 3 (not pl. 5, fig. 1; text fig. 10).

Pterygocythereis miocenica VAN DEN BOLD, 1967a, p. 310, pl. 1, figs. 19a, b.

Pterygocythereis sp. aff. *P. americana* (Ulrich and Bassler). SWAIN, 1968, p. 19, 20, pl. 2, figs. 7a-d; text fig. 18.

DIMENSIONS: Left valve, length .80-.92 mm, height .41-.45.

REMARKS: Benson and Coleman (1963) placed crested and uncrested forms in *P.* cf. *P. americana* (Ulrich and Bassler), stating that the crested specimens were heteromorphs and the uncrested were technomorphs. Hazel (1967) stated that Benson and Coleman's uncrested forms and Curtis's (1960) *Pterygocythere* sp. "represent an undescribed species, whereas the crested forms probably are *Pterygocythereis americana.*" Van den Bold (1967) described the new species, *P. miocenica,* but excluded all of Benson and Coleman's specimens and the crested form reported by Curtis (1960). This writer agrees that the crested forms of Benson and Coleman and Curtis should be excluded from the synonymy of *P. miocenica;* however, the uncrested forms are conspecific with *P. miocenica.* In this study there are distinctly crested and uncrested molts at all stages; these molts can be referred to *P. americana* and *P. miocenica,* respectively, as a growth series for each can be reconstructed.

OCCURRENCE: Stations 4, 7, 37, 43-45, 50, 59, 63, 64, 66, 68, 70, 72-76, 78, 81, 83, 88, 89, 91, 92, 94, 97-99, 102-107, 109-112, 115, 117, and 118.

ECOLOGY: Water depths of 42 to 204 feet; clayey silt and silty clay; foraminiferal P/B ratios of .01 to .35.

PTERYGOCYTHEREIS AMERICANA (Ulrich and Bassler), 1904
Plate 7, figure 7

Pterygocythereis cornuta var. *americana* ULRICH and BASSLER, 1904, p. 122, pl. 37, figs. 29-33.

Pterygocythereis americana (Ulrich and Bassler). HAZEL, 1967, p. 19, 20, pl. 2, figs. 7a-d; text fig. 18.

DIMENSIONS: Length .82 mm; height .46 mm.

REMARKS: The single carapace is damaged, therefore, a width measurement is not meaningful. These specimens are smaller than those examined by Ulrich and Bassler (1904) and Hazel (1967), but are similar to those illustrated by Benson and Coleman (1963).

OCCURRENCE: Stations 3, 4, 7, 9, 68-70, 72, 74, 87, 89, 91, 92, 94, 96, and 98.

ECOLOGY: Water depths of 84 to 204

feet; sediments were of varied textures; foraminiferal P/B ratios of .03 to .35.

Subfamily CYTHERETTINAE
Triebel, 1952
Genus PROTOCYTHERETTA Puri, 1958

PROTOCYTHERETTA KARLANA
(Howe and Pyeatt, 1935)
Plate 7, figure 4

Cytheretta karlana HOWE and PYEATT, 1935, p. 34, 35, pl. 1, figs. 30, 34; pl. 3, figs. 3, 4. SMITH, 1941, p. 279, VAN DEN BOLD, 1946, p. 105, pl. 9, fig. 18. SWAIN, 1951, p. 46, pl. 6, fig. 19.
Cytheretta reticulata EDWARDS, 1944, p. 525, pl. 8, figs. 7-10. BROWN, 1958, p. 67, pl. 6, fig. 13. PURI, 1958b, p. 184, table 1.
Paracytheretta karlana (Howe and Pyeatt). PURI, 1952a, p. 209, pl. 40, figs. 3-5; text fig. 8.
Protocytheretta karlana (Howe and Pyeatt). PURI, 1958b, p. 184, table 1. POOSER, 1965, p. 38, 39, pl. 12, figs. 3, 7-10.
?*Cytheretta danaiana* (Brady). CURTIS, 1960, p. 478, pl. 2, (top) fig. 2 (Not *Cythere danaiana* Brady, 1869, p. 124, pl. 14, figs. 13, 14).

DIMENSIONS: Carapaces, ?female, length .82-.94 mm; height .46-.52 mm; width .36-.45 mm; ?males, length .80-.88 mm; height .44-.48 mm; width .35-.40 mm.

REMARKS: There had been much controversy as to the relationship of *Protocytheretta karlana* (Howe and Pyeatt, 1935), and *P. reticulata* (Edwards, 1944). Swain (1951) considered the two to be conspecific, but Puri (1953c) did not; Pooser (1965) placed *P. reticulata* in synonymy with *P. karlana*. Edwards (1944) stated that *P. reticulata* differs from *P. karlana* "in being less pointed posteriorly and possessing stronger ornamentation." In the current study material, the ornamentation is highly variable from long thin pits to the "elongate rectangular or triangular pits" described by Edwards. Ridges between the pits are also variable from being low and indistinct to prominent. Length/height ratios have not been mentioned previously in regard to sexual dimorphism in these forms; apparent males are relatively lower, perhaps accounting for some fo the previous controversy as to the size ranges of *P. karlana* and *P. reticulata*. Inasmuch as size and ornamentation differences have been used to separate the species, the variations noted here seem to negate the use of those criteria in this case. Left valve dimensions listed by Puri (1952a) for *P. karlana* indicate a size close to Edward's holotype for *P. reticulata* (see Text Figure 5).

The variation in ornamentation is believed to be caused by postmortem erosion of the long thin pits. At the edge of each pit, on well preserved specimens, is a ragged edge of mineral material. The edges tend to cover the center of the pit with a thin layer (note that the edges never touch, however.) As the surface of the specimen is eroded, the thin edge of each pit is removed, thus, each pit appears to be enlarged and less elongate; experimental erosion of the valve surface verifies this process.

This species differs from *P. pumicosa* (Brady, 1866) in not having the central

PLATE 6

Figure Page

1-2. *Actinocythereis vandenboldi* Kontrovitz, n. sp. 81
1. Holotype, HVH 9510, carapace, right view (100X)
2. Paratype, HVH 9511, right valve (100X)
3-4. *Munseyella bermudezi* van den Bold *louisianensis* Kontrovitz, n. subsp. 80
3. Holotype, HVH 9516, carapace, right view (100X)
4. Paratype, HVH 9517, carapace, right view (100X)
5. *Pellucistoma magniventra* Edwards, HVH 9494, left view (100X) 78
6. *Actinocythereis gomillionensis* (Howe and Ellis), HVH 9501, left valve (100X) 81
7. *Buntonia*? sp., HVH 9502, left valve (100X) 84
8. *Munseyella* sp., HVH 9503, damaged carapace, left view (200X) 80

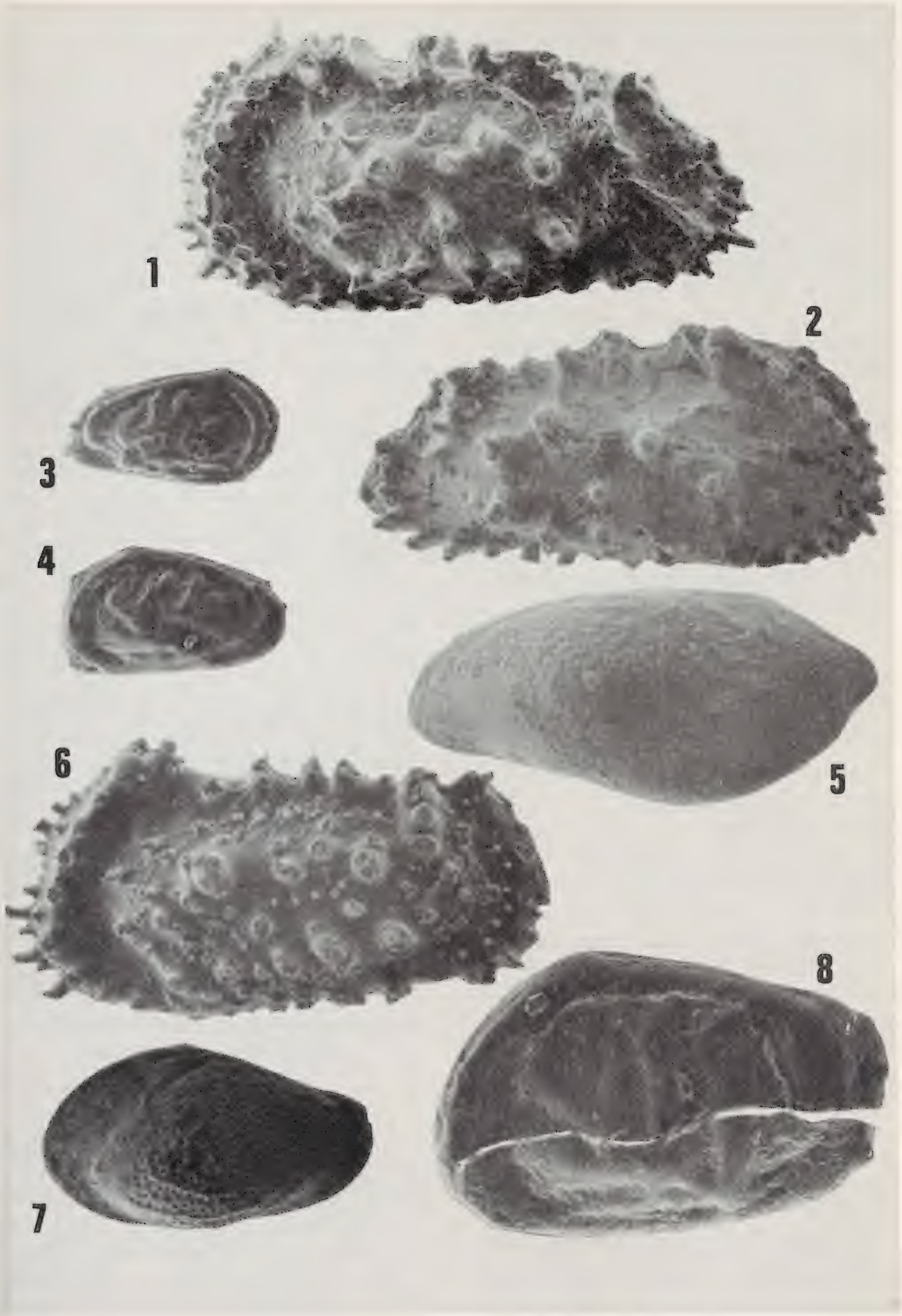
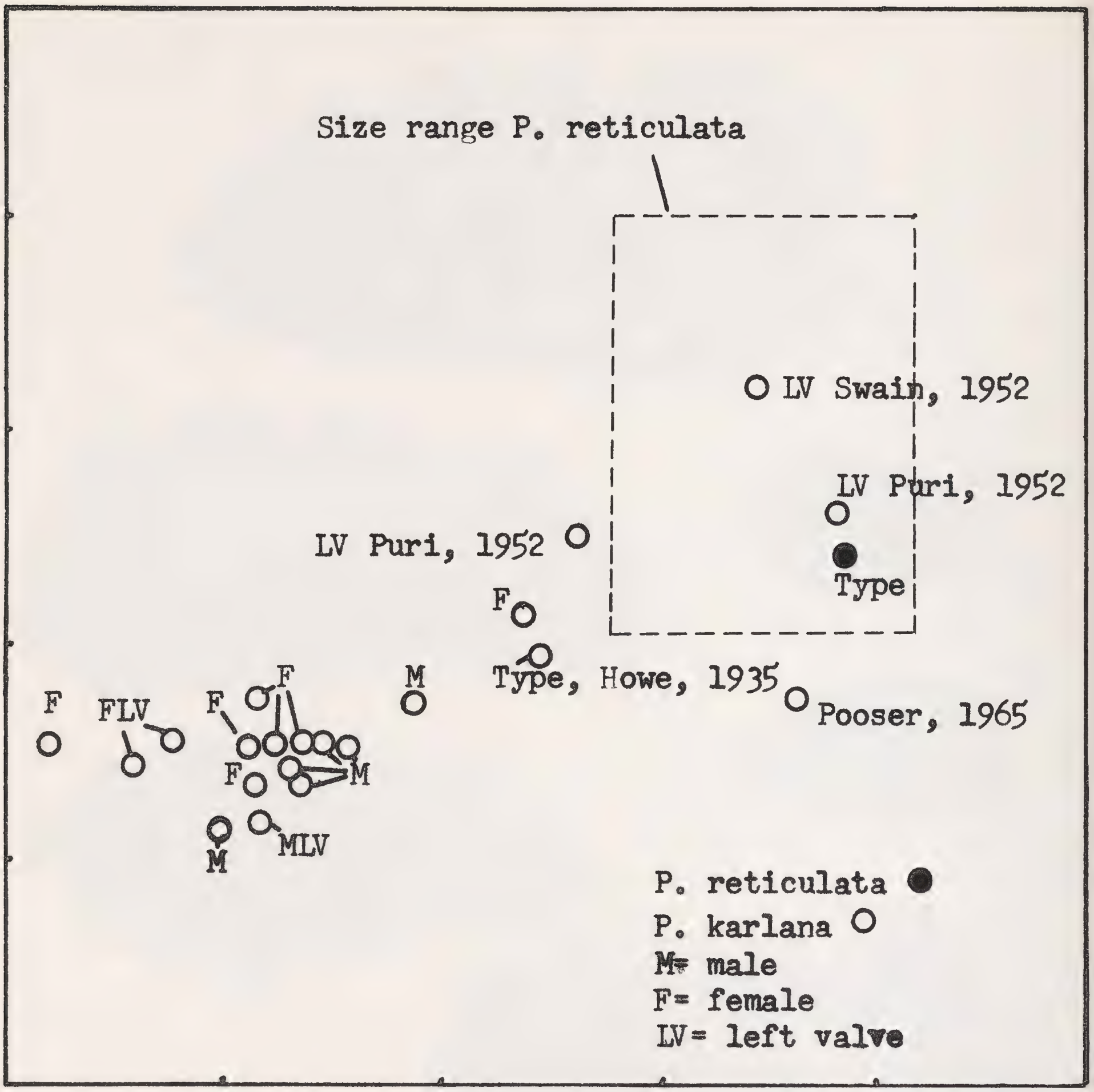


PLATE 6



Text figure 5. Size comparison of *Protocytheretta karlana* and *P. reticulata.*

ridges joined posteriorly to form loops. (*Cythere pumicosa* Brady, 1866, is a senior synonym of *Cythere danaiana* Brady, 1869, *fide* van den Bold, 1971, personal communication).

OCCURRENCE: Stations 4, 7, 40, 43, 45, 60, 63, 64, 67-76, 81-84, 87, 88, 98, 96-102, 104-112, and 117.

ECOLOGY: Water depths of 42 to 192 feet, with 95% of the valves at less than 125 feet; sediments varied from clayey silt to silty clay and sand-silt-clay; foraminiferal P/B ratios of .01 to .60.

PROTOCYTHERETTA MONTEZUMA (Brady) LOUISIANENSIS Kontrovitz, n. subsp.

Plate 7, figures 5, 6

DIAGNOSIS: Distinguished from *Protocytheretta montezuma montezuma* (Brady, 1869), by having reticulations between the lateral ribs, especially at and in front of mid-length.

DESCRIPTION: Elongate-ovoid, heavily calcified, medium size. Dorsal margin is nearly straight at center, marked convexities at cardinal angles. Ventral margin is sinuous with a concavity just in front of mid-length. Anterior margin broadly rounded below mid-height, more obliquely rounded above. Posterior margin broadly rounded

below mid-length, acutely rounded above, greatest length above middle.

Dorsal view: Elongate, arrow-shaped, greatest width at about one-fifth of length from posterior; tapers to produced posterior and with convexity to acutely rounded anterior. Left valve larger than right at cardinal angles; right valve highest at mid-length (this is obscure in left lateral view, however).

Surface: Anterior is smooth, remainder ribbed with some reticulations. Three prominent ridges, including two lateral that may be joined posteriorly with a thin sinuous loop; a dorsal rib that is arched at posterior dorsal area forming carapace outline there; dorsal rib more subdued on right valve, but distinct. Coarse reticulations between ribs (that is, cross ribs). Ventral area below lateral ribs is striate, without cross ribs.

Sexual dimorphism: Apparently males are relatively lower and longer. ?Males are also highly compressed at posteroventral area of right valve.

Internal view: Hinge, right valve, a large pyramidal anterior tooth, followed by a circular socket open to interior, long straight crenulate groove, and elongate-ovate posterior tooth. Hinge, left valve, swelling of selvage at anterior in front of a large socket; socket is enclosed dorsally and anteriorly but open at its posteroventral limit; socket followed by a large smooth tooth that merges into a crenulate median bar; median bar terminates abruptly without swelling at its posterior; behind bar is an elongate socket that follows the curved outline of the valve. Inner margin is wide, irregular, inward flexure at anteroventral area. A large indentation and enlargement forming a knob-like projection of flange of left valve is just in front of mid-length (at venter). Radial pore canals few, sinuous above mid-length at anterior, more numerous and simply curved below; may be enlarged near outer margin; posterior, radial pore canals, many and closely spaced, nearly straight to curved. Central muscle scars are in a small circular depression inside valve; four oval adductors, in a subvertical row; elongate frontal scar.

HOLOTYPE: HVH 9524, figured specimen, ?female RV, length .84 mm, height .43 mm.

PARATYPES: HVH 9525, figured specimen, ?female carapace, length .80 mm, height .44 mm, width .39 mm. HVH 9526, ?male RV, length .84 mm, height .41 mm; HVH 9527, juvenile RV, length .72 mm, height .39 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°49.0'N, 90°36.6'W, station 56 of this study.

DIMENSIONS: Carapace, ?female, length .78 mm; height .46 mm; width .41 mm; carapace, ?male, length .86 mm; height .47 mm; width .40 mm. Left valve, ?male, length .87 mm; height .49 mm.

MATERIAL: Adults, four carapaces, 39 valves; juveniles, two carapaces, 44 valves.

REMARKS: The internal features of this form are much like *Cytheretta sahnii* Puri, 1952a, as illustrated by Benson and Coleman (1963, p. 25, Text Figure 12), but *Cytheretta sahnii* differs in having no surface ornamentation. *Cytheretta alexanderi* Howe and Chambers, 1935, differs in lacking coarse reticulations and has small anterior denticles. *Cytheretta calhounensis* Smith, 1941, has more lateral ribs (four or five) and does not have a finely striate venter; *C. calhounensis* has only four of five ribs near the venter compared to about 15 on the subspecies described here.

This species is similar in outline to *Cytheretta howei* Swain, 1946, but can be distinguished by the smooth anterior one-third of the carapace, the prominent dorsal ridge on the left valve, the distinct reticulations between the two lateral ribs, and the smaller size. This subspecies differs from *Protocytheretta montezuma montezuma* (Brady) as indicated above.

OCCURRENCE: Stations 4, 25, 37, 46, 48, 50, 53, 56, 78, 114, 115, and 117-120.

ECOLOGY: Water depths of 14 to 132 feet; sediments varied from sands to silty clays; foraminiferal P/B ratios of .005 to .05.

Subfamily ?
Genus BASSLERITES Howe, 1937

REMARKS: The genus *Basslerites* Howe, 1937, has previously been placed in the family Hemicytheridae (subfamily Campylocytherinae). Plusquellec and Sandberg (1969) restudied the subfamily Campylocytherinae and concluded that the genus *Basslerites* "does not fit in the subfamily. . ." Indeed, those writers stated that "the carapace details of species of *Basslerites* require placement of that genus among the Trachyleberididae." They did not erect a new subfamily in the Trachyleberididae or assign *Basslerites* to an existing subfamily.

BASSLERITES VOKESI Kontrovitz, n. sp.
Plate 4, figures 7, 8

Basslerites cf. *B. berchoni* (Brady). CURTIS, 1960, p. 478, pl. 1, fig. 5. (Not *Cythere berchoni* Brady, 1879, p. 117, pl. 14, figs. 3, 4).

DIAGNOSIS: Distinguished by the combination of the presence of posterolateral depressions, its small size, convex dorsum and venter in the female, large anterior vestibule, numerous radial

pore canals, and pronounced sexual dimorphism for this genus.

DESCRIPTION: Ovate, moderately calcified, small. Female, lateral view, dorsal margin is smoothly convex; ventral margin convex; convexity increases behind mid-point. Anterior margin is evenly rounded; posterior margin broadly rounded below mid-height, acutely rounded above. Greatest length above mid-height; greatest height is at one-third of total length from the posterior. Left valve is larger than right, except at extreme anterior and posterior. Males differ by having nearly straight, subparallel ventral and dorsal margins, in being relatively lower, and having a more distinct posterior cardinal angle than females.

Dorsal view: Females, elongate-ovate, with greatest width at one-fourth of total length from posterior; sides are convex and taper gently forward and rapidly to posterior. Anterior is acutely rounded; posterior broadly rounded and has lateral depressions. Males, greatest width is just behind mid-point.

Surface is smooth except at about posterior one-fifth where a shallow surface depression forms an asymmetrical "V" with the apex directed forward and positioned below mid-height. Surface in depression is not smooth but is uneven with a beaded appearance and large normal pore canals.

Internal view: Hinge, right valve, a high rounded anterior tooth; elongate oval socket open posteriorly to the interior; a narrow crenulate arched median groove; and a large, curved, weakly crenulate tooth at posterior cardinal angle. In dorsal view, the anterior tooth is elevated on a ramp and slightly pointed at its anterior. Left valve, with a circular anterior socket closed ventrally and anteriorly by a low ridge; medial bar enlarges to a long, slender tooth anteriorly, with a distinct groove positioned just above the tooth; medial bar, arched near mid-length, but straight posteriorly to cardinal angle; a shallow groove is present only above straight portion of the bar; an elongate, curved socket at the posterior cardinal angle, open to interior. Marginal area: Inner lamella, wide at anterior, narrow elsewhere; large vestibule in lower anterior. Radial pore canals are numerous (22 to 26); long and sinuous above vestibule, short and nearly straight below vestibule; funnel-like internal openings and rarely two canals per opening. Selvage, at anterior is low and slightly removed from outer margin; ventrally, selvage is high, sharp, and deflected upward in front of mid-length; near outer margin at posterior. Muscle scars, four adductors and "J"-shaped frontal scar.

HOLOTYPE: HVH 9481, figured specimen, female left valve, length .41 mm, height .23 mm, width .18 mm.

PARATYPES: HVH 9482, figured specimen, male carapace, length .41 mm, height .21 mm, width .16 mm; HVH 9483, female LV, length .41 mm, height .24 mm; HVH 9484, female RV, length .40 mm, height .21 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°43.8'N, 95°05.4'W, station 103 of this study.

DIMENSIONS: Females, carapaces, length .39-.42 mm; height .23-.24 mm; width .17-.19 mm; males, carapaces, length .39-.41 mm; height .20-.21 mm; width .15-.16 mm.

MATERIAL: Adults, 32 carapaces, 26 valves; juveniles, one carapace.

REMARKS: *Basslerites cuspidatus* van den Bold, 1966a, is similar in some characters, but is larger, has less convex dorsal and ventral margins, and different hingement. Van den Bold (1966a) stated that the hinge and margins in *B. cuspidatus* are the same as the type species, *B. miocenicus* (Howe, 1935). Unlike *B. miocenicus,* the species described here has a distinct ridge that closes the anterior socket of the left valve. *B. minutus* van den Bold, 1958, has a small anterior vestibule, no groove above the anterior tooth in the left valve, and does not

PLATE 7

Figure Page

1. *Echinocythereis margaritifera* (Brady), HVH 9515, right valve (100X) 84
2. *Pterygocythereis miocenica* van den Bold, HVH 9521, left valve (100X) 85
3. *Henryhowella* ex. gr. *asperrima* (Reuss), HVH 9522, right valve (100X) 84
4. *Protocytheretta karlana* (Howe and Pyeatt), HVH 9523, right valve (100X) 86
5-6. *Protocytheretta montezuma* (Brady) *louisianensis* Kontrovitz, n. subsp. 88
   5. Holotype, HVH 9524, right valve (100X)
   6. Paratype, HVH 9525, carapace, left view (100X)
7. *Pterygocythereis americana* (Ulrich and Bassler), HVH 9528, left valve (100X) 85
8-9. *Cytherella vermilionensis* Kontrovitz, n. sp. 92
   8. Paratype, HVH 9530, carapace, ?male, left view (100X)
   9. Holotype, HVH 9529, carapace, ?female, left view (100X)

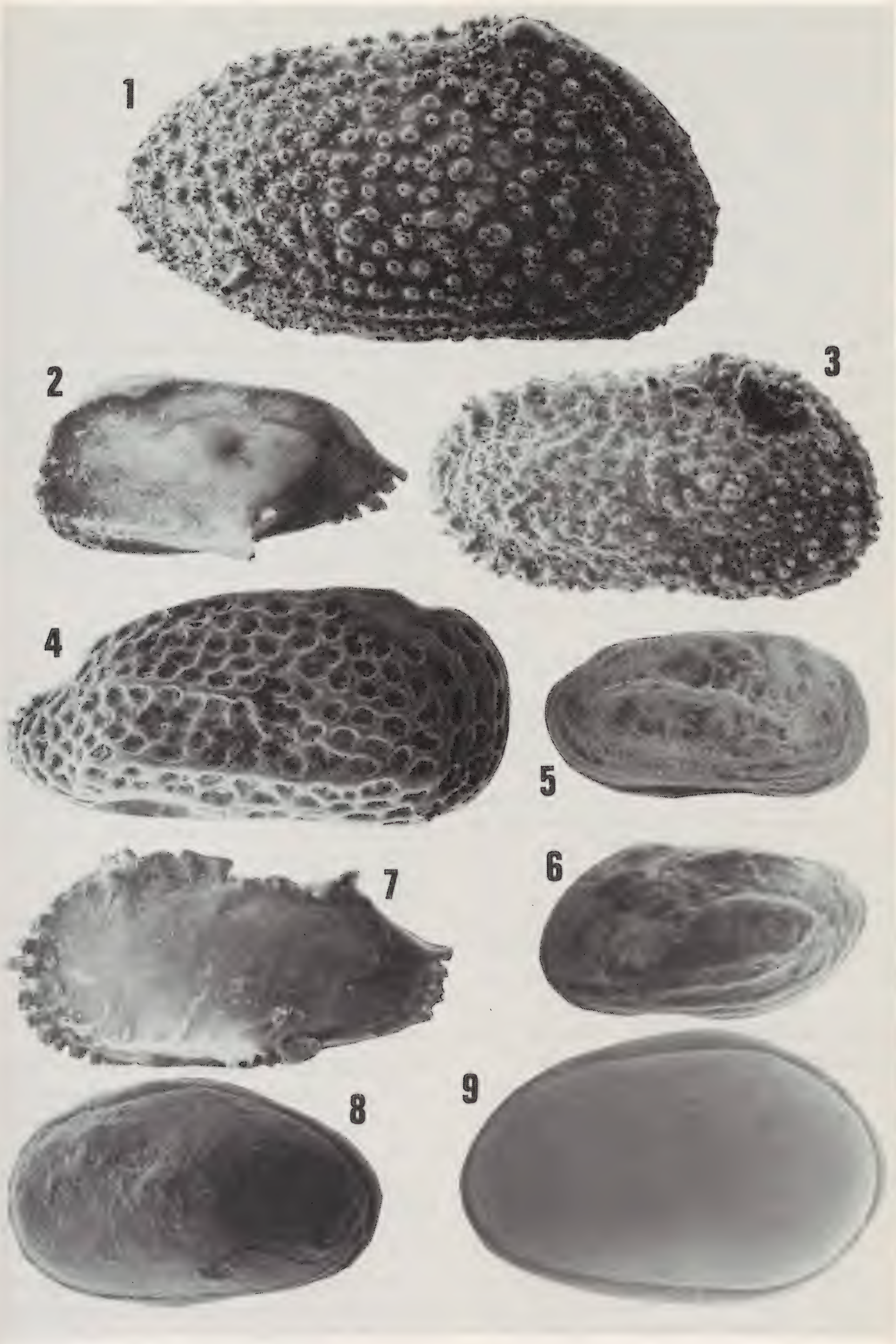


PLATE 7

have an oval socket at the anterior in the right valve. *B. berchoni* (Brady, 1870) has a different lateral outline, no posterolateral depression, and a small vestibule.

This species is named in honor of Dr. Harold E. Vokes for his outstanding contributions to Paleontology.

OCCURRENCE: Stations 4, 5, 9, 14, 25, 28-31, 41, 46, 64, 67, 73-75, 78, 82, 84, 94, 95, 100, 103-107, 109, 110, 113, and 114.

ECOLOGY: Water depths of 48 to 520 feet; clayey silt and silty clays; foraminiferal P/B ratios of .01 to .27. Previously reported (Curtis, 1960) as occurring at 90 feet or deeper.

Suborder PLATYCOPINA Sars, 1866
Family CYTHERELLIDAE Sars, 1866
Genus CYTHERELLA Jones, 1849

CYTHERELLA cf. C. HARPAGO Kornicker, 1963
Plate 8, figure 1

Cytherella harpago KORNICKER, 1963, p. 67, text. figs. 30-32, 39-42.

Cytherella sp. aff. *C. harpago* Kornicker, MORALES, 1966, p. 20, pl. 1, figs. 2a-c.

DIMENSIONS: Right valve, ?female, length .75 mm; height .42 mm.

REMARKS: The specimens reported by Morales (1966) are smaller and more finely punctate than Kornicker's type material; juveniles from the present study are also more finely punctate than the type material. Specific identification was not possible, here, because of the poorly preserved condition of the valves.

OCCURRENCE: Stations 7, 9, 22, 70, 72, and 98.

ECOLOGY: Water depths of 99 to 148 feet; sediment varied from silty clays to sand-silt-clay; foraminiferal P/B ratios .01 to .13. Previous reports list depths of 1 to 16 feet and salinities that are brackish or marine.

CYTHERELLA VERMILIONENSIS Kontrovitz, n. sp.
Plate 7, figures 8, 9

?*Cytherella* sp. VAN DEN BOLD, 1950, p. 80, pl. 18, figs. 1a-e.

DIAGNOSIS: Distinguished in the female, by its highly arched dorsum, with greatest height at mid-length, the broadly rounded posterior, and the distinct forward slope of the dorsal margin of the left valve only.

DESCRIPTION: Carapace, female, ovoid, heavily calcified, small. Lateral view, dorsal margin is highly arched; ventral margin less convex. Anterior and posterior margins are broadly rounded. Height about .7 times length. Right valve forms carapaces outline, greatest overlap is at anterodorsal and mid-ventral areas. Left valve is broadly rounded posteriorly, has a slightly convex venter, and a dorsal margin that slopes downward toward the anterior; the slope of the dorsal margin is pronounced, beginning one-third of length from posterior. Surface: widely scattered normal pore canals.

Dorsal view: Spatulate, greatest width one-third of length from posterior, slight concavity at one-fourth length from anterior. Posterior is broadly rounded, anterior compressed and acutely rounded.

Sexual dimorphism: Males are smaller, narrower in dorsal view; with a nearly straight and sloping dorsal outline in lateral view, as compared to the convex dorsum of the female. Males are highest anterior to mid-length.

Internal view: Hinge, right valve, a simple groove to receive edge of left valve. Muscle scars typical of genus, a feather-shaped cluster.

HOLOTYPE: HVH 9529, figured specimen, damaged female carapace, length .60 mm, height .43 mm.

PARATYPES: Figured specimen, HVH 9530, ?male carapace, length .60 mm, height .35 mm, width .25 mm; HVH 9531, female RV, length .60 mm, height .40 mm; HVH 9532, male LV, length .58 mm, height .36 mm; HVH 9533, female LV, length .55 mm, height .35 mm.

TYPE LOCALITY: Louisiana continental shelf, 28°30.0'N, 92°08.4'W, station 98 of this study.

DIMENSIONS: Carapaces, female, length .56-.60 mm; height .39-.43 mm; width .31-.33 mm; males, .52-.58 mm; height .35-.36 mm; width .24-.25 mm.

MATERIAL: Adults, 20 carapaces, 84 valves; juveniles, five carapaces, 14 valves.

REMARKS: *Cytherella* sp. van den Bold, 1950, is similar in lateral outline, but differs by being more tumid in dorsal view and in being larger (female, length .69 mm; height .49 mm; width .39 mm). *Cytherella turgidula* Alexander, 1934, *C. tuberculifera* Alexander, 1929, *C. tumidosa* Alexander, 1934, and *C. ovata* (Roemer, 1840), are larger, less highly arched, and are not broadly rounded at the posterior but rather are bluntly pointed. *C. fredricksburgensis* Alexander, 1932, is not broadly rounded at the posterior and in dorsal view the female is

not anteriorly compressed. *C. guasarensis* van den Bold, 1956, a Paleocene species, is not broadly rounded at the posterior and has the greatest height in front of the mid-length. *C. polita* Brady, 1869, is less highly arched and the left valve does not slope as in the female of the species described here. Benson and Coleman, 1963, described *C. grossmani* with the juveniles appearing similar to the males in this new species.

This species is named for its occurrence near Vermilion Bay, Louisiana.

OCCURRENCE: Stations 4, 6, 9, 28, 43-45, 48, 50, 55, 59-61, 63, 64, 70, 71, 74-76, 78, 81-83, 98, 101, 103, 104, 106, 107, 109, 111, 117, and 118.

ECOLOGY: Water depths of 54 to 294 feet, with 95% of the valves recovered from 54 to 150 feet; sediments varied, from silty clay to sand-silt-clay; foraminiferal P/B ratios of .005 to .17.

Genus CYTHERELLOIDEA
Alexander, 1929

CYTHERELLOIDEA aff.
C. CASTLEBERRYENSIS
Howe and Law, 1936
Plate 8, figure 2

?*Cytherelloidea castleberryensis* HOWE and LAW, 1936, p. 20, pl. 1, fig. 18; pl. 2, fig. 4.

DIMENSIONS: Females, right valves, length .70-.71 mm; height .39-.40 mm; male, right valve, length .65 mm; height .36 mm.

REMARKS: These specimens lack a short longitudinal rib near the venter, just above the concavity, that is present on *C. castleberryensis* Howe and Law, 1935; other aspects of the ornamentation, valve size, and shape are similar. Benson and Coleman (1963) collected *Cytherelloidea* cf. *C. sarsi* Puri, 1960, noting variability in surface reticulations and ribbing. The specimens in the present study display variability only in the reticulations just behind the anterior rim; the areas between the ribs are never reticulate as is *C. sarsi.* Benson and Coleman noted similarities between their *Cytherelloidea* cf. *C. sarsi* and *C. castelberryensis,* but stated that their specimens lack "a short ridge near the ventral margin and" have "a rounded rather than truncate posterior margin." The specimens reported in the present study are poorly preserved and more must be obtained if specific identification is to be made.

OCCURRENCE: Water depths of 120 to 198 feet; clayey silts and silty clays; foraminiferal P/B ratios of .03 to .13.

The species listed below are represented by only a few specimens and are illustrated on the plates indicated for future comparisons.

Species	Plate and Figure	Water Depth (In feet)
Candona cf. *C. marchina* Hartwig	1, 8	40
Candona cf. *C. patzcuaro* Tressler	1, 5	50
Psuedocythere aff. *P. fragilis* Sars	2, 2	108-192
Cyprideis cf. *C. salebrosa* van den Bold	2, 1	14-60
Haplocythereidea cf. *H. bradyi* (Stephenson)	2, 3	204
Perissocytheridea excavata Swain	2, 4	54-102
Perissocytheridea rugata Swain	8, 5	54-88
Hemicytherura cf. *H. sablensis* Benson & Coleman	4, 4	192
Megacythere cf. *M. johnsoni* (Mincher)	8, 6	186
Megacythere cf. *M. stephensoni* (Puri)	8, 7	42-132
Neomonoceratina mediterranea (Ruggieri)	8, 4	54
Eucythere sp.	8, 3	132-135

VIII. STATION LOCATIONS

Station	Latitude North	Longitude West	Water Depth in Feet	Sediment Texture
1	29°32.4'	88°31.8'	144	sand-silt-clay
2	30°12.0'	88°32.4'	150	sand-silt-clay
3	29°29.0'	88°31.8'	174	sand-silt-clay
4	29°27.0'	88°40.2'	132	sand-silt-clay
5	29°19.8'	88°42.0'	186	sand-silt-clay
6	29°16.8'	88°55.2'	120	sand-silt-clay
7	29°15.0'	88°53.4'	192	sand-silt-clay
8	29°14.4'	88°57.6'	720	sand-silt-clay
9	29°13.2'	88°56.4'	108	sand-silt-clay
10	29°03.6'	88°54.6'	282	silty clay
11	29°03.0'	88°59.4'	174	silty clay
12	29°00.0'	88°58.2'	194	silty clay
13	28°52.8'	89°02.4'	630	silty clay
14	28°52.8'	89°12.6'	420	silty clay
15	28°50.4'	89°00.1'	768	silty clay
16	28°50.4'	89°02.4'	660	silty clay
17	28°48.6'	89°06.6'	788	silty clay
18	28°50.4'	89°09.6'	510	silty clay
19	28°48.0'	89°11.4'	600	silty clay
20	28°50.4'	89°10.2'	420	silty clay
21	28°51.6'	89°11.4'	360	silty clay
22	28°54.6'	89°10.8'	198	silty clay
23	28°57.0'	88°13.2'	90	silty clay
24	28°51.6'	89°14.4'	306	silty clay
25	28°57.0'	89°15.6'	108	silty clay
26	28°55.2'	89°16.8'	168	silty clay
27	28°54.0'	89°16.8'	192	silty clay
28	28°48.0'	89°21.8'	300	silty clay
29	28°45.0'	89°33.6'	306	silty clay
30	28°48.0'	89°36.0'	270	silty clay
31	28°49.2'	89°33.6'	264	silty clay
32	28°38.6'	89°28.6'	240	slty-cly; cly-slt
33	28°51.6'	89°28.0'	200	clayey silt
34	28°52.4'	89°27.2'	115	clayey silt
35	28°53.0'	89°26.7'	85	clayey silt
36	28°53.6'	89°26.3'	40	clayey silt
37	28°59.0'	89°32.4'	100	sand-silt-clay
38	29°05.9'	89°36.1'	55	sandy silt
39	28°57.9'	89°37.9'	165	sand-silt-clay
40	28°59.2'	89°43.6'	130	silt, clayey silt
41	28°57.5'	89°50.2'	118	clay, clayey silt
42	28°53.9'	90°03.4'	90	clayey silt
43	28°46.9'	90°06.8'	145	silty clay
44	28°49.2'	90°10.2'	90	clayey silt
45	28°43.2'	90°15.1'	115	clayey silt
46	28°49.2'	90°14.4'	78	clayey silt
47	28°58.4'	90°14.7'	45	?silty clay
48	28°52.2'	90°16.8'	68	clayey silt
49	28°39.0'	90°21.5'	115	clayey silt
50	28°33.0'	91°48.6'	66	sand
51	28°52.2'	90°27.0'	60	clayey silt
52	28°58.8'	90°27.5'	25	silty clay
53	28°48.6'	90°31.8'	60	sand
54	28°42.0'	90°33.0'	54	sand
55	29°33.9'	90°34.2'	107	clayey silt
56	28°49.0'	90°36.6'	60	sand
57	28°48.0'	90°43.2'	60	sand
58	28°42.0'	90°39.6'	54	sand

Station	Latitude North	Longitude West	Water Depth in Feet	Sediment Texture
59	28°34.2’	90°47.4’	72	clayey silt
60	28°28.2’	90°45.6’	114	clayey silt
61	28°30.2’	90°51.5’	108	clayey silt
62	28°28.2’	90°57.0’	108	clayey silt
63	28°28.8’	91°03.0’	108	clayey silt
64	28°36.0’	90°57.0’	69	clayey silt
65	28°41.4’	91°01.8’	42	sand
66	28°32.1’	90°17.5’	103	sand
67	28°33.9’	91°44.1’	100	sand
68	28°28.8’	91°53.4’	162	sand
69	28°94.4’	91°55.2’	156	sand
70	28°33.0’	91°48.6’	138	sand
71	28°36.6’	91°48.6’	126	clayey silt
72	28°40.2’	91°43.8’	99	clayey silt
73	28°42.0’	91°41.4’	90	clayey silt
74	28°45.6’	91°43.8’	84	clayey silt
75	28°45.6’	91°43.8’	84	clayey silt
76	28°48.6’	91°45.6’	72	clayey silt
77	28°54.0’	91°39.6’	60	clayey silt
78	28°54.0’	91°31.6’	54	clayey silt
79	28°59.4’	91°41.4’	42	clayey silt
80	28°58.8’	91°43.0’	48	clayey silt
81	28°48.0’	91°47.4’	88	clayey silt
82	28°48.0’	91°47.4’	88	clayey silt
83	28°45.0’	91°52.2’	90	clayey silt
84	28°41.4’	91°53.4’	102	clayey silt
85	28°39.4’	91°55.7’	95	clayey silt
86	28°24.6’	92°01.2’	180	silty clay
87	28°26.4’	92°03.0’	174	silty clay
88	28°25.2’	92°05.4’	180	silty clay
89	28°23.4’	92°07.2’	186	silty clay
90	28°20.4’	92°13.2’	198	silty clay
91	28°20.4’	92°17.4’	198	silty clay
92	28°19.2’	92°23.4’	204	silty clay
93	28°21.6’	92°18.6’	192	silty clay
94	28°22.8’	92°18.6’	186	silty clay
95	28°25.8’	92°18.6’	180	silty clay
96	28°28.8’	92°13.2’	168	clayey silt
97	28°29.4’	92°08.4’	156	clayey silt
98	28°33.0’	92°08.4’	138	clayey silt
99	28°38.4’	92°07.2’	132	clayey silt
100	28°39.6’	92°01.2’	120	clayey silt
101	28°40.8’	92°05.4’	120	clayey silt
102	28°43.2’	92°07.2’	114	clayey silt
103	28°43.8’	92°05.4’	108	clayey silt
104	28°43.8’	91°59.4’	105	clayey silt
105	28°43.2’	91°56.8’	102	clayey silt
106	28°42.6’	91°56.4’	102	clayey silt
107	28°48.6’	91°53.4’	102	clayey silt
108	28°48.6’	91°57.0’	84	clayey silt
109	28°51.0’	91°58.2’	78	clayey silt
110	28°52.2’	92°02.4’	84	clayey silt
111	28°57.0’	92°19.8’	84	clayey silt
112	29°07.8’	92°15.0’	42	clayey silt
113	29°01.2’	92°11.4’	66	clayey silt
114	29°04.8’	92°07.2’	48	clayey silt
115	29°02.4’	92°05.4’	54	clayey silt
116	29°02.8’	92°03.6’	54	clayey silt
117	28°54.0’	91°53.4’	66	clayey silt
118	28°57.0’	91°51.0’	60	clayey silt

Station	Latitude North	Longitude West	Water Depth in Feet	Sediment Texture
119	29°00.0'	91°48.0'	60	clayey silt
120	29°06.0'	91°42.0'	14	sand
121	29°07.9'	91°27.6'	20	sand-silt-clay
122	29°17.8'	91°26.9'	15	silty clay
123	29°35.0'	91°14.1'	40	no data

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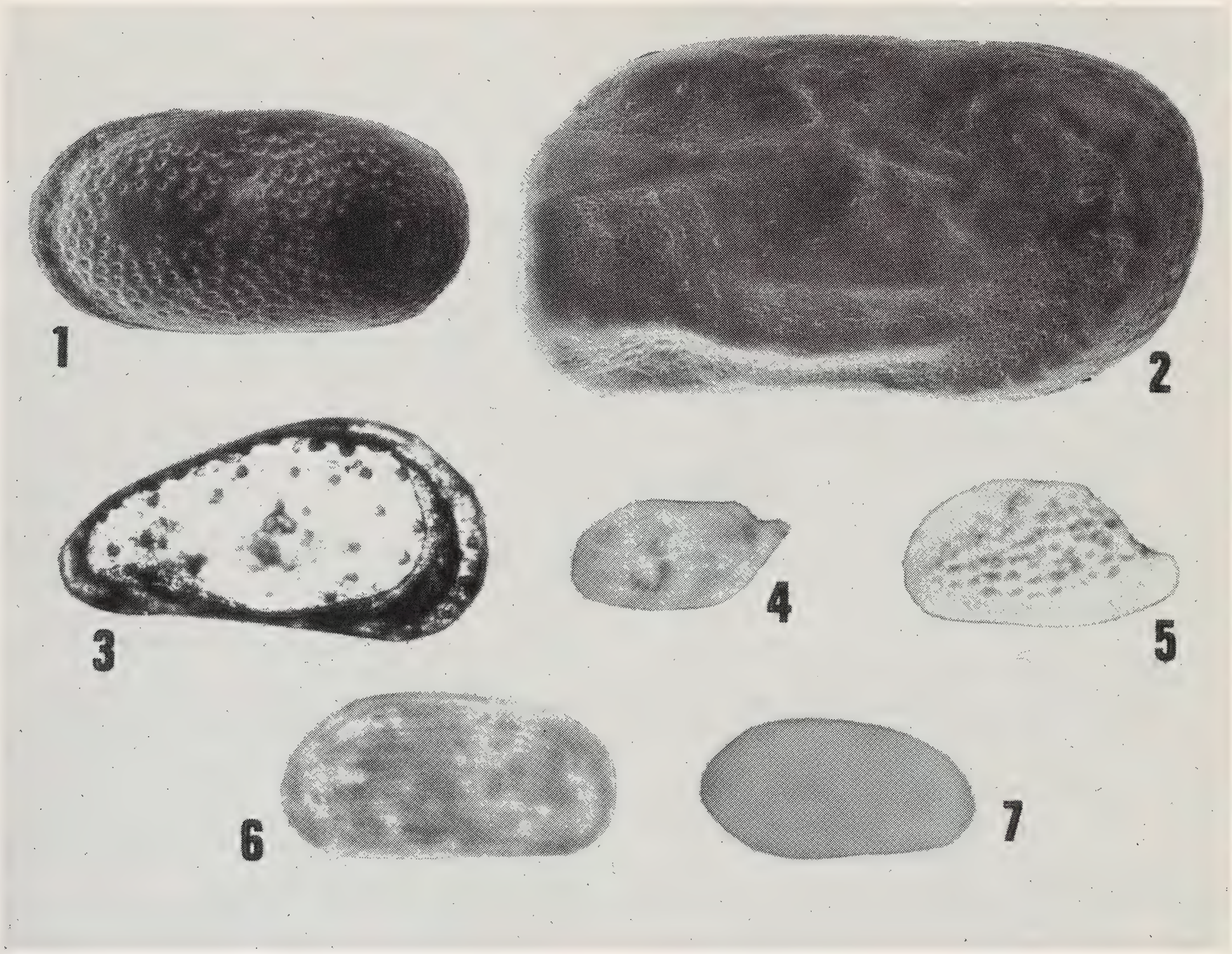

PLATE 8

Figure Page

1. *Cytherella* cf. *C. harpago* Kornicker, HVH 9534, left valve (100X) 92
2. *Cytherelloidea* aff. *C. castleberryensis* Howe and Law, HVH 9535, right valve (100X). 93
3. *Eucythere* sp., left valve (112X) 93
4. *Neomonoceratina mediterranea* (Ruggieri), left valve (54X) 93
5. *Perissocytheridea rugata* Swain , damaged right valve (54X) 93
6. *Megacythere* cf. *M. johnsoni* (Mincher), left valve (70X) 93
7. *Megacythere* cf. *M. stephensoni* (Puri), right valve (54X) 93

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REVIEWS

STATISTICAL METHODS FOR THE EARTH SCIENTIST, An Introduction, by Roger Till. Published by John Wiley & Sons, New York and Toronto, 1974, xii + 154 pp., $11.75

This is a textbook on the application of statistics to the earth sciences. It is intended as a short and simplified approach to this subject. It is applicable not only to the study of rocks and fossils, but to the processes of weathering and sedimentation, the description of landforms, and the measurement of engineering properties of rocks and soils. It can be used with a simple algebra background and all calculations can be made with a small calculator; this is most desirable and makes the book more generally useful.

A TEXTBOOK ON GEONOMY, by J. A. Jacobs. Published by John Wiley & Sons, New York, 1975, ix + 328 pp., $19.75

Curiously, the author has obscured the nature of his book by choosing an unfamiliar term to characterize his subject matter. Surely, the content of the volume is more significant and its utilization more important than the desire of the author to revive another forgotten (and best left at rest) synonym for a subdivision of the earth sciences. Many potential readers will never open the cover of this volume and learn that it is concerned with the Physics of the Earth.

Recent developments in geophysics and the planetary sciences make it most necessary to revise our views of the physics and chemistry of the earth and its place in the solar system. This book is an attempt to present an updated review of these subjects and to present a modern approach to the broader questions of the origin of the earth, its moon, and the solar system itself. Regrettably, any book on a rapidly developing and dynamic discipline will be out-of-date before publication; this one was in press more than two years. However, it does present a fresh and useful approach to this subject. It will prove useful to those who find their way past the title.

THE MECHANICS OF FROZEN GROUND, by N. A. Tsytovich. Published by McGraw-Hill Book Company, New York, 1975, xix + 426 pp., $34.50

This is a translation of the Russian edition (Moscow, 1973) of a work based on many years of work by many investigators on permafrost in Siberia and the construction problems related to frozen ground. Written by a leading pioneer in this field, the book was translated by George K. Swinzow, one of the leading students of frozen ground mechanics in the United States. The subjects of constructing foundations and dams, as well as highway construction on permafrost are treated, and solutions to these engineering problems are suggested.

—H.C.S.

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Volume 12, Number 3 September 15, 1976

CENOZOIC MURICIDAE OF THE WESTERN ATLANTIC REGION
PART VII – *CALOTROPHON* AND *ATTILIOSA*
EMILY H. VOKES p. 101

ON THE IDENTITY OF TWO SUPPOSED FACIOLARIID GASTROPODS, *FUSUS MEXICANUS* REEVE, 1848, and *PERISTERNIA NODULOSA* A. ADAMS, 1855
ROBERT C. BULLOCK p. 133

THE CRYSTAL RIVER FORMATION (EOCENE) AT MARTIN, MARION COUNTY, FLORIDA
DAVID NICOL, GRAIG D. SHAAK and JOHN W. HOGANSON p. 137

THE GENUS *VOORTHUYSENIELLA* (PROBLEMATICA) AT LITTLE STAVE CREEK, ALABAMA p. 145

and

VOORTHUYSENIELLA (PROBLEMATICA) FROM THE PLEISTOCENE OF THE TEXAS CONTINENTAL SHELF
DREW HAMAN and BARRY KOHL p. 157

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION
XIX – ON THE PRESENCE OF *GASTROCHAENA (SPENGLERIA)* (MOLLUSCA: BIVALVIA) p. 161

and

XX – A SECOND SPECIES OF *PETRICOLA (PETRICOXENICA)* (MOLLUSCA: BIVALVIA) p. 163
HAROLD E. VOKES

A NEW SPECIES OF *BUKRYASTER* FROM THE UPPER CRETACEOUS OF SOUTHEAST OKLAHOMA
ANTHONY KRANCER p. 166

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PART VII – *CALOTROPHON* AND *ATTILIOSA*

EMILY H. VOKES
TULANE UNIVERSITY

CONTENTS

Page

I. ABSTRACT 101
II. INTRODUCTION 101
III. ACKNOWLEDGMENTS 105
IV. SYSTEMATIC DESCRIPTIONS 105
V. LOCALITY DATA 126
VI. LITERATURE CITED 130

ILLUSTRATIONS

TEXT FIGURE 1 103
TEXT FIGURE 2 114
PLATE 1 113
PLATE 2 115
PLATE 3 117
PLATE 4 119
PLATE 5 121
PLATE 6 123
PLATE 7 125
PLATE 8 127

I. ABSTRACT

The two small genus-groups of *Calotrophon* Hertlein and Strong and *Attiliosa* Emerson are shown to be recently derived lines, presumed to come from a *Poirieria (Panamurex)* ancestor sometime during the Miocene. As emerging groups both demonstrate an amount of specific variability unusual in the Muricinae. There are only six species in *Calotrophon:* one from the eastern Pacific (the type) and five western Atlantic, of which two are described herein. These are *C. ascensus,* n. sp., from the Pleistocene of Costa Rica, and *C. andrewsi,* n. sp., from the Recent fauna of Yucatán and south Florida. There are but five species of *Attiliosa,* three western Atlantic and two eastern Pacific. All of the western Atlantic species are treated systematically.

II. INTRODUCTION

The two genus-groups treated in this paper are considered together because they are believed to be descendants of a common ancestor (see text fig. 1). In an earlier work (Vokes, 1971, p. 7) the writer suggested that *Attiliosa* was a subgenus of *Calotrophon* but more detailed investigation has indicated that they are parallel lineages and not especially closely related. Both have a fairly heavy intritacalx, or chalky outer layer, although not as heavy as that seen in

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WILLIAM K. EMERSON, American Museum of Natural History, New York, New York
GEORGE E. RADWIN, Natural History Museum, San Diego, California

members of the genera *Aspella* and *Dermomurex,* treated previously (Vokes, 1975). Both are but vaguely muricine in appearance with the varices and spines, so characteristic of the group as a whole, reduced as to be frequently completely lacking. This is, in fact, the "tag-end" of the subfamily and one might say that the species included are most unlikely murices. In neither group is there a great number of species, and in *Attiliosa* we have yet to find any great number of individuals. One final trait they share is the fact that morphologically the species of both groups are inordinately variable, unlike most murices, which are normally very stable. This may be a reflection of the fact that they are youthful, emerging genera and are still in a plastic stage.

Both groups are found in the western Atlantic and the eastern Pacific only, the types of both genera being Recent Pacific species. Both groups have only recently been recognized as valid generic units and the species of both have multiple names* and a chequered history of generic assignment.

The geologic history of each is very brief. *Attiliosa* first occurs in the (?) upper Miocene of Santo Domingo; *Calotrophon* is first seen in the lower Pliocene of south Florida. At their initial appearance both are represented by a Recent species and the changes since that time have been limited. It would seem that we are witnessing the appearance of two new lineages in the subfamily.

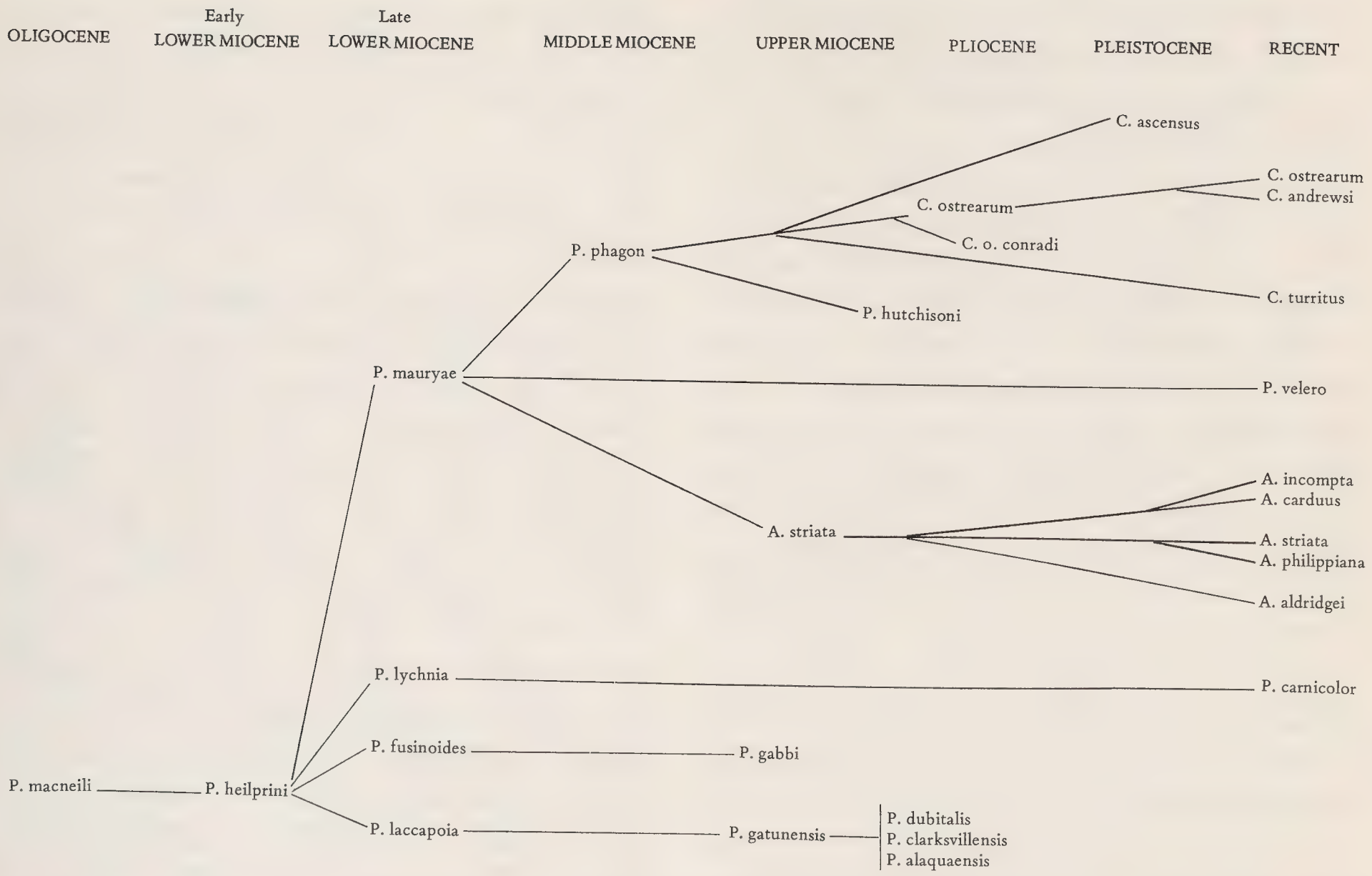
If one goes back into the Oligocene and lower Miocene of the southeastern United States, we see that there is a well defined line of murices, starting with *Poirieria (Panamurex) macneili* Vokes, in the Vicksburg fauna. This species gave rise to a similar form, *P. heilprini* (Cossmann), in the lowermost Miocene (Tampa Limestone, Aquitanian). In turn, we see in the Burdigalian Chipola Formation four species that all seem to be immediately derived from this ancestral line. The relationship of the various species was discussed by the writer in a previous paper (Vokes, 1970) and all were figured there. Of the four Chipola species the least typical is *P. mauryae* Vokes, the smallest of the group.

Dr. George Radwin (personal communication) has suggested that perhaps *P. mauryae* should not be included in *Panamurex,* but rather in *Calotrophon.* It is true that the type species, *P. gatunensis* (Brown and Pilsbry), is at one extreme of the group, *P. mauryae* at the other. The completely typical *Panamurex* is characterized by having a strong labral tooth, but no spines encircling the siphonal canal. In addition to the type, there are several other fossil species with these characteristics, but the line is now extinct. The remainder of the species placed in *Panamurex* by the writer (Vokes, 1970) differ from the typical form in having small spines encircling the siphonal canal but lacking the labral tooth. It is this group for which Rehder (1946, p. 142) originally proposed the name *Dallimurex.* In seeking a modern representative for the type species, he chose *Poiriera (Paziella) nuttingi* (Dall), which lacks the strong spiral ornamentation and the labial denticles of the *Panamurex* group, and so the subgenus remained nameless until Woodring (1959) proposed *Panamurex.*

The absence or presence of the spines circling the canal does not seem to be of more than specific value in the genus *Poiriera* as a whole. In *Poirieria* s.s. (type species, *Murex zelandicus* Quoy and Gaimard) they are missing; in the subgenus *Paziella* (type species, *Murex pazi* Crosse) they occur in some species and are lacking in others, but there seems little reason to erect yet a third subgenus for those that do not, although such a name is available if deemed necessary — *Bathymurex* Clench and Pérez Farfante, 1945 (type species, *Murex atlantis* Clench and Pérez Farfante).

All of the species referred to the subgenus *Panamurex* are characterized by a general lack of spiral and axial ornamentation except for the major cords and the varices. The surface of the shell between the major spirals is notably smooth. There are no scabrous axial growth lines and secondary spiral cords are greatly reduced. These

*As further evidenced in the note by R. C. Bullock, which follows in this volume.



Text figure 1. Inferred relationship between *Poirieria (Panamurex), Calotrophon,* and *Attiliosa.*

species are all marked by having usually four strong denticles at the anterior end of the columella wall. This combination of strong primary spiral cords, with smooth interspaces, and labial denticles also appears in the *Attiliosa* line. In fact, the Dominican holotype of *A. striata* (Gabb) is so much like *P. mauryae* (compare pl. 1, fig. 1, and text figure 2), if it were not for the subsequent specimens one would probably include *A. striata* in *Panamurex*. It is less ornamented even than *P. mauryae* and the denticles are greatly reduced, usually appearing only in fully mature individuals.

Panamurex mauryae also seems to be the link to another lineage that diverged in the form of *P. phagon* (Gardner) (pl. 1, fig. 5), a species that occurs in the Oak Grove and Shoal River formations of Florida. This species is elaborately sculptured with both axials and secondary spirals. It lived in a shallow sandy environment, and how much the differences seen are due to ecology and how much to genetics is not known. It would appear, however, that *P. phagon* is a logical candidate for the immediate ancestor of the *Calotrophon* line.

The decision to place *P. phagon* with the ancestral *Panamurex* group rather than the derivative *Calotrophon* group is based upon several considerations, as the species has certain features of both. It has the sculpture and lack of spines of *Calotrophon,* but it also has varices and the labial denticles of *Panamurex*. When one compares the early whorls of *P. phagon* (pl. 1, fig. 5a) and *C. ostrearum* (Conrad) (pl. 1, figs. 6, 9c) the differences are striking. The resemblance of the adults may well be parallelism rather than close relationship. The oldest examples of *C. ostrearum* (pls. 1, 2) from the lower Pinecrest Beds actually bear very little resemblance to *P. phagon,* it is the modern forms that suggest *P. phagon* perhaps should be placed in *Calotrophon.*

The *P. phagon* line did not change into *Calotrophon*, this much is certain. In the Melajo Clay of Trinidad (either late Miocene or early Pliocene) there is another small species much like *P. phagon,* which has been named *"Calotrophon* (?)" *hutchisoni* by Jung (1969, p. 494). *"C." hutchisoni* (see pl. 1, figs. 3, 4) was referred by the present writer to *Panamurex* because of the similari-

ties to *P. phagon.* Again, examination of the early whorls (pl. 1, fig. 4) shows how little it resembles contemporaneous specimens of *C. ostrearum* and how closely it resembles *P. phagon* and *P. mauryae.*

Specimens of true *Calotrophon* first appear in the lower Pinecrest Beds (lower Pliocene) of southern Florida. The earliest examples, such as those figured from TU localities 729 and 932, do not especially look like modern representatives of the species, having distinctly rounded shoulders and never any shoulder spines. There are only occasionally even small spinelets on the siphonal canal. These early shells all tend to have a rounded outline, fine ornamentation, and never a hint of varices.

The labial denticles of *Panamurex* have all but disappeared; a few specimens (pl. 2, figs. 3 & 4) may be seen with two or three much reduced denticles but most specimens have only a single tooth at the entrance to the siphonal canal. After these oldest occurrences no specimens, of all the hundreds examined, ever have more than the single tooth on the inner lip.

The morphological function, if any, of these labial denticles cannot be ascertained. It is not a reflection of underlying spines as it might seem to be at first glance. The members of *Panamurex,* such as *P. laccapoia* and *P. gatunensis,* that have no spines on the siphonal canal still have very strong labial denticles. They do not seem to be related to the spiral cords either, because it is possible to break away the columellar callus and see that the columellar wall has been polished smooth and then the callus is laid down on top of it. The denticles have no particular orientation in regard to the previously existing spiral cords. This same type of denticle occurs among various families of Gastropoda and is usually of at least subgeneric importance. In the Muricinae such denticles are found in *Panamurex* and *Attiliosa,* although they are reduced in the latter. In the Muricopsinae they occur in the type genus, *Muricopsis,* and in *Risomurex.* But they are also present in the Cymatiidae, Bursidae, and numerous other totally unrelated families. They may represent an approximation on the part of the animal to the columellar folds of the Volutacea, or they may serve a completely different function.

The earliest described species of both *Calotrophon* and *Attiliosa* were placed for a long time in the genus *Muricidea* Swainson. This name is one that has a history of being misunderstood. It was originally proposed by Swainson (1840, p. 65) for those shells having the progressive growth stages marked by longitudinal ridges. He specifically stated that "the type of *Muricidea* is the harp-like *Murex magellanicus*" and hence the name is a junior objective synonym of *Trophon* Montfort, the type of which is also *M. magellanicus* Gmelin (by original designation, = *Buccinum geversianum* Pallas). In his list of species assigned to this genus, Swainson included *"Murex" hexagonus* Lamarck. Subsequent authors decided that *Muricidea* should be applied to the species now referred to *Muricopsis,* and in 1880 (p. 335) Jousseaume cited the type of *Muricidea* as *Murex hexagonus.* In 1882 Bucquoy, Dautzenberg, and Dollfus (p. 19) proposed *Muricopsis* for that group, with *Murex blainvillei* Payraudeau as type; however, the usage of the name *Muricidea* persisted in the literature for some years thereafter as a sort of "waste-basket" for muricine species that could not be placed into any other genus-group.

There have been excellent recent papers on both genera being considered here: *Attiliosa* by Emerson (1968) and *Calotrophon* by McLean and Emerson (1970). Therefore, there is no necessity to repeat what has been said there. The observation may be made, however, that the radulae of the two genera (*Attiliosa:* Emerson, 1968, figs. 2, 3; *Calotrophon:* McLean and Emerson, 1970, figs. 8, 9) are noticeably different. This is a strong corroboration of the geological history, which suggests that the two groups are not as closely related as formerly thought by the writer (Vokes, 1971, p. 7). *Attiliosa* has what might be called a "normal" muricine radula, no different from the *Pterynotus-Poirieria* group from whence it is assumed to be derived. *Calotrophon* is marked by having extremely long cusps on the rachidian tooth but the overall pattern is still muricine rather than trophonine. Both groups also have a

normal muricine operculum with an apical nucleus. In spite of the marginally muricine appearance of the shell, therefore, it seems obvious that both genera are to be placed in the subfamily Muricinae.

III. ACKNOWLEDGMENTS

For a small group of species, this paper involved an unusual amount of borrowing of specimens. *Attiliosa,* especially, is poorly represented in collections, and almost every specimen in this part of the study was provided by outside sources. The writer is particularly grateful to a group of Florida collectors who provided most of the figured specimens. These include: Mr. and Mrs. Robert C. Hoerle and Mrs. Virginia Lee, West Palm Beach; Mrs. Margaret C. Kennedy, Delray Beach; and Mrs. Barbara A. Steger, Tampa. Mrs. Ruth Fair, Honolulu, Hawaii, also generously contributed a paratype to the collection. In addition, a number of institutions provided comparative material and thanks are expressed to: Earl A. Shapiro, Academy of Natural Sciences, Philadelphia; Barry Roth, California Academy of Sciences; Kenneth J. Boss, Museum of Comparative Zoology, Harvard University; Joseph Rosewater and Thomas R. Waller, U.S. National Museum. Special gratitude is reserved for William K. Emerson, American Museum of Natural History; George E. Radwin and Anthony D'Attilio, San Diego Natural History Museum; Robert C. Bullock, University of Rhode Island; and William G. Lyons, Florida Dept. of Natural Resources, Marine Research Laboratory, St. Petersburg, Florida; all of whom provided not only specimens but a great deal of valuable information.

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IV. SYSTEMATIC DESCRIPTIONS

Phylum MOLLUSCA
Class GASTROPODA
Subclass PROSOBRANCHIA
Order NEOGASTROPODA
Suborder STENOGLOSSA
Superfamily MURICACEA
Family MURICIDAE
Subfamily MURICINAE
Genus CALOTROPHON
Hertlein and Strong, 1951

Calotrophon HERTLEIN and STRONG, 1951, Mollusks West Coast of Mexico and Central Amer., pt. 10, *in* Zoologica, v. 36, p. 87.

Type species: *Calotrophon bristolae* Hertlein and Strong [= *Tritonalia turrita* Dall], by original designation.

Pseudosalpinx OLSSON and HARBISON, 1953, Acad. Nat. Sci. Phila., Mon. 8, p. 254.

Type species: *Urosalpinx floridana* Conrad [= *Murex ostrearum* Conrad], by original designation.

Hertleinella BERRY, 1958, Leaflets in Malac., v. 1, no. 16, p. 95.

Type species: *Hertleinella leucostephes* Berry [= *Tritonalia turrita* Dall], by original designation.

CALOTROPHON OSTREARUM (Conrad)

Plate 1, figs. 6-9; Plate 2, figs. 1-6;
Plate 3, figs. 1-9; Plate 4, figs. 1-11;
Plate 5, figs. 1-11

Murex ostrearum CONRAD, 1846, Acad. Nat. Sci. Phila., Proc., v. 3, p. 25 [Feb., 1846, *fide* Sherborn]; 1846, Amer. Jour. Sci., (N.S.) v. 2, p. 397.
Urosalpinx floridana CONRAD, 1869, Amer. Jour. Conch., v. 5, p. 106, pl. 12, fig. 4.
Murex ostrearum Conrad. TRYON, 1880, Man. Conch., v. 2, p. 135.
Urosalpinx floridana Conrad. TRYON, 1880, Man. Conch., v. 2, p. 153, pl. 39, fig. 486 (after Conrad, 1869).
Muricidea floridana (Conrad). DALL, 1884, U.S. Natl. Mus., Proc., v. 6, p. 326; 1889, Harvard Mus. Comp. Zool., Bull., v. 18, p. 212 (with *Murex ostrearum* in queried synonymy); 1889, U.S. Natl. Mus., Bull. 37, p. 120; 1890, Wagner Free Inst. Sci., Trans., v. 3, pt. 1, p. 189; 1892, *ibid,* v. 3, pt. 2, p. 212.
Muricidea floridana var. *attenuata* DALL, 1890, Wagner Free Inst. Sci., Trans., v. 3, pt. 1, p. 149.
Urosalpinx floridana Conrad. BAKER, 1891, Acad. Nat. Sci. Phila., Proc. for 1891 [v. 43], p. 51.
Muricidea ostrearum (Conrad). DALL, 1902, U.S. Natl. Mus., Proc., v. 24, p. 505, pl. 30, fig. 2 (with *U. floridana* in synonymy).
Muricidea ostrearum (Conrad). MAURY, 1922, Bulls. Amer. Paleontology, v. 9, no. 38, p. 98.

Muricidea floridana (Conrad). WEISBORD, 1926, Nautilus, v. 39, p. 86.
Muricidea floridana (Conrad). MANSFIELD, 1930, Fla. Geol. Surv., Bull. 3, p. 86.
Muricidea ostrearum (Conrad). JOHNSON, 1934, Boston Soc. Nat. Hist., Proc., v. 40, p. 116.
Muricidea ostrearum (Conrad). JAUME, 1946, Soc. Malac. Habana, Revista, v. 4, p. 106.
Muricopsis floridana (Conrad). GARDNER, 1948, U.S. Geol. Surv. Prof. Paper 199B, p. 225.
Muricidea ostrearum (Conrad). M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 11, pl. 14, fig. 1.
Cantharus (Pseudosalpinx) floridana (Conrad). OLSSON and HARBISON, 1953, Acad. Nat. Sci. Phila., Mon. 8, p. 254, pl. 37, figs. 2, 2a (syntypes of *U. floridana*).
Cantharus (Pseudosalpinx) perplexus OLSSON and HARBISON, 1953, Acad. Nat. Sci. Phila., Mon. 8, p. 255, pl. 37, figs. 1, 1a.
Muricopsis ostrearum (Conrad). ABBOTT, 1954, Amer. Seashells, p. 211, fig. 47G (after Dall, 1902).
Muricopsis ostrearum (Conrad). PERRY and SCHWENGEL, 1955, Marine Shells Western Coast Florida, p. 155, pl. 31, fig. 218.
Muricopsis ostrearum (Conrad). RADWIN and WELLS, 1968, Bull. Mar. Sci., v. 18, p. 77, figs. 6 (radula), 20-G (shell).
Urosalpinx floridana (Conrad). JUNG, 1969, Bulls. Amer. Paleontology, v. 55, no. 247, p. 294.
Pseudosalpinx ostrearum (Conrad). S. E. HOERLE, 1970, Tulane Stud. Geol. Paleont., v. 8, no. 2, p. 63.
Calotrophon ostrearum (Conrad). MCLEAN and EMERSON, 1970, Veliger, v. 13, p. 60, plate figs. 11-14 [fig. 11, lectotype-*Urosalpinx floridana;* fig. 12, holotype-*Cantharus perplexus*]; text figs. 15, 16 [fig. 15, radula; fig. 16, operculum].
[Calotrophon] ostrearum (Conrad). E. H. VOKES, 1971, Bulls. Amer. Paleontology, v. 61, no. 268, p. 77 (with *U. floridana* in synonymy).
Muricopsis ostrearum (Conrad). MORRIS, 1973, Field Guide to Shells . . . Third Edition (W. J. Clench, Ed.), p. 193, pl. 52, fig. 20.
Calotrophon ostrearum (Conrad). ABBOTT, 1974, Amer. Seashells, 2nd Ed., p. 188, fig. 1965 (after Dall, 1902).

Diagnosis: "Fusiform, with revolving ribs alternated in size; and with longitudinal wrinkles; spire elevated, scalariform; base umbilicated; within livid." (Conrad, 1846-*Murex ostrearum*).

"Fusiform, longitudinal ribs distant, prominent, thick, rounded; spire prominent, scalariform; whorls 6, penultimate whorl with 3 prominent revolving lines; last volution profoundly ribbed and having 10 conspicuous prominent revolving lines; caudal ridge prominent, curved; beak recurved, longitudinal prominent wrinkled lines are conspicuous over the whole surface; aperture and columella purple; labrum with 7 lines within." (Conrad, 1869-*Urosalpinx floridana*).

Dimensions of lectotype: height 29.2 mm (Olsson and Harbison, 1953, pl. 37, expl.).

Lectotype *(U. floridana):* ANSP 36551 (designated, McLean and Emerson, 1970, p. 60).

Type locality: Tampa Bay, Florida (original designation for both *ostrearum* and *floridana).*

Occurrence: Duplin Formation, (?) middle Pliocene; North Carolina. Waccamaw Formation, upper Pliocene; North and South Carolina. Pinecrest Beds, lower and middle Pliocene; Caloosahatchee Formation, upper Pliocene; Bermont Formation, lower Pleistocene; Anastasia and Ft. Thompson formations, upper Pleistocene; Florida. Recent, Florida and Yucatán, only.

Figured specimens: Plate 1, fig. 6, USNM 711115; height 10.6 mm, diameter 5.2 mm; locality, St. Joseph's Sound, Florida, Recent. Plate 1, fig. 7, USNM 240642; height 27.8 mm, diameter 15.2 mm; fig. 8, USNM 240643; height 26.8 mm, diameter 13.0 mm; locality TU 729. Plate 1, fig. 9, USNM 240644; height 27.9 mm, diameter 14.4 mm; Plate 2, fig. 1, USNM 240645; height 32.7 mm, diameter 17.4 mm; locality TU 932. Plate 2, fig. 2, USNM 240646; height 29.6 mm, diameter 14.7 mm; fig. 3, USNM 240647; height 27.2 mm, diameter 13.7 mm; fig. 4, USNM 240648; height 22.3 mm, diameter 10.2 mm; fig. 5, USNM 240649; height 27.2 mm, diameter 13.7 mm; fig. 6, USNM 240650; height 24.1 mm, diameter 11.9 mm, locality TU 730. Plate 3, fig. 1, USNM 240654; height 26.2 mm, diameter 12.5 mm; fig. 2, USNM 240655; height 24.4 mm, diameter 12.8 mm; fig. 3, USNM 240656; height 20.2 mm, diameter 11.7 mm; locality TU 1000. Plate 3, fig. 4, USNM 240657; height 24.7 mm, diameter 14.0 mm; fig. 5, USNM 240658; height 24.9 mm, diameter 13.2 mm; fig. 6, USNM 240659; height 27.4 mm, diameter 13.2 mm; fig. 7, USNM 240660; height 24.6 mm, diameter 12.0 mm; locality TU 519. Plate 3, fig. 8, USNM 240661; height 31.5 mm, diameter 15.0 mm; locality TU 539B. Plate 3, fig. 9, USNM 647695; height 20.0 mm, diameter 10.7 mm; locality USGS 24123, 1½ miles NE of Fairmont, Robeson Co., North Carolina. Plate 4, fig. 1, USNM 240662; height 21.5 mm, diameter 10.4 mm; fig. 2, USNM 240663; height 21.4 mm, diameter 10.8 mm; locality TU 726. Plate 4, fig. 3, USNM 240664; height 20.6 mm, diameter 10.4 mm; fig. 4, USNM 240665; height 22.3 mm, diameter 11.1 mm; locality TU 767. Plate 4, fig. 5, USNM 240666; height 24.0 mm, diameter 12.0 mm; fig. 6, USNM 240667; height 25.3 mm, diameter 13.0 mm, locality TU 727. Plate 4, fig. 7, USNM 240668; height 25.3 mm, diameter 12.0 mm; fig. 9, USNM 240670; height 35.3 mm, diameter 17.0 mm; fig. 10, USNM 240671; height 21.5 mm, diameter 11.5 mm; locality TU 978. Plate 4, fig. 8, USNM 240669; height 28.3 mm, diameter 14.8 mm; locality TU 759. Plate 4, fig. 11, USNM 240672; height 17.3 mm, diameter 9.4 mm; locality TU 201. Plate 5, fig. 1, USNM 240673; height 24.6 mm, diameter 11.7 mm; fig. 2, USNM 240674; height 22.0 mm, diameter 11.2 mm; locality TU 580. Plate 5, fig. 3, USNM 240675; height 24.1 mm, diameter 12.5 mm; locality TU 777. Plate 5, fig. 4, USNM 240676; height 20.0 mm, diameter 10.7 mm; fig. 5, USNM 240677; height 19.0 mm, diameter 10.1 mm; locality TU 529A. Plate 5, fig. 6, USNM 240678; height 25.7 mm, diameter 13.7 mm; locality TU 977. Plate 5, fig. 7, AMNH 100637A; height 27.9 mm, diameter 14.4 mm; locality, off Egmont Key, Tampa Bay, Florida, 25 fms. Plate 5, fig. 8, USNM 711108; height 22.4 mm, diameter 11.6 mm; locality TU R-9. Plate 5, fig. 9, USNM 711109; height 25.3 mm, diameter 12.8 mm; fig. 10, USNM 711110; height 24.4 mm, diameter 12.3

mm; locality TU R-220. Plate 5, fig. 11, FSBC I 11240; height 23.2 mm, diameter 14.0 mm; locality, off Ft. Myers, Florida, 20 fms.

Other occurrences: TU locality nos. 79, 200, 202, 203, 283, 520, 522, 523, 525, 527, 529B, 532, 536, 539A, 540, 579, 582, 583, 725, 728, 729, 731, 733, 736, 740, 745, 746, 747, 750, 752, 754, 755, 768, 769, 770, 788, 790, 792, 793, 796, 797, 803, 808, 815, 816, 870, 933, 936, 973, 981, 982, 985, 987, 988, 989, 990, 1044, 1177. Recent occurrences: TU locality nos. R-17, R-20, R-44, R-46, R-105, R-164, R-304, R-306, R-350, R-351, R-352, R-353, R-354.

Discussion: As the lengthy occurrence list indicates, *C. ostrearum* is one of the more ubiquitous species in the Plio-Pleistocene beds of southern Florida. However, other than in Florida, the species is extremely rare in the fossil record. Dall (1892, p. 212) listed the species (as *Muricidea floridana* – USNM 112324) occurring at Todd's Ferry, on the Waccamaw River, near Conway, South Carolina, and in the Tulane Collections there are three examples from the Waccamaw Formation at Old Dock, North Carolina (TU 870). In the USNM collections there is a single example from the Duplin Formation of North Carolina (figured here, pl. 3, fig. 9), but otherwise the species is unknown outside of the southern Florida area. The form that occurs in the Jackson Bluff Formation (TU 60) in northern Florida is a distinct subspecies, *C. ostrearum conradi* (Mansfield).

In the Recent fauna it is slightly more widespread, reaching as far as the Yucatán Peninsula. Baker (1891, p. 51) and Weisbord (1926, p. 86) reported it from Progreso and Campeche, respectively. Jaume (1946, p. 106), in a report on the mollusks of Yucatán, noted that the species did not occur at Cabo Catoche and merely repeated Weisbord's locality. However, in the Tulane Collections there is a single example from Cabo Catoche (TU R-304) and, in addition, we have collected specimens from a number of other Mexican stations (see list above) ranging from near Champoton, Campeche, to Isla Mujeres, Quintana Roo.

Ecologically, there seems to be a direct relationship between the shallow-water occurrences of *C. ostrearum* and mangrove swamps. All of the specimens that the writer has collected personally have been in the vicinity of mangroves or the adjacent lagoons, such as Tarpon Bay on Sanibel Island, Florida (TU R-220). All of the Yucatán specimens collected alive, without exception, were found at low tide crawling on the shell-rubble exposed among the mangrove roots. Certainly, the type locality, Tampa Bay, has large areas of mangroves along the south side. The paleoecologic implication of this association can be seen when one notes that during the Pliocene *C. ostrearum* ranged much farther north than it does today, with specimens reported from North and South Carolina. It is assumed, therefore, that mangrove swamps also extended into these areas.

Today, on the Atlantic coast of Florida the species has been reported by Maury (1922, p. 98) to range as far north as St. Augustine. This marks the northern limit of the black mangrove *(Avicennia germinans);* the red *(Rhizophora mangle)* and white *(Laguncularia racemosa)* mangroves not ranging past approximately Daytona Beach (Carlton, 1974, p. 289, fig. 5). On the Gulf side of Florida *C. ostrearum* gets as far north as Apalachee Bay (Radwin and Wells, 1968, p. 73). There is a single deep-water specimen from the sub-Recent "mudlump" fauna (TU 977) off the mouth of the Mississippi River (where, incidentally, the black mangrove does grow). However, in general, the present range of the species is the east and west coasts of Florida, the Yucatán Peninsula, and apparently nowhere else.

The generic placement of *"Murex" ostrearum* has been a problem to workers as is shown by the complicated synonymy above. Conrad first assigned the form to *"Murex"* and then later, not realizing the variability of the species, redescribed it as *"Urosalpinx."* There is a certain superficial resemblance to the members of *Urosalpinx,* although it is obvious from Conrad's description that he realized it was more elaborately ornamented than *Urosalpinx* is normally, hence his emphasis on the "prominent" axial ribs and spiral cords, especially those on the siphonal canal. Subsequently, Dall (1884, p. 326) observed that the "operculum is muricoid and it is not a *Urosalpinx* [which has a purpuroid operculum]," assigning the species to the genus *Muricidea.*

Olsson and Harbison, recognizing that the group to which *"Murex" ostrearum* belongs was in need of a name, proposed the subgenus *Pseudosalpinx* in 1953 (p. 254), with the type species as *"Urosalpinx floridana."* However, what they had not realized, and what would not be recognized for another 20 years, was that the Atlantic species was congeneric with a west Mexican species named as the type of a new genus by Hertlein and Strong in 1951 (p. 87). This Mexican species was named *Calotrophon bristolae,* and it was not until 1970 that McLean and Emerson recognized the generic affinities of the two disjunct occurrences and, at the same time, noted an older name for *C. bristolae* was *"Tritonalia" turrita* Dall, 1919.

Although all of the specimens figured herein, ranging in age from early Pliocene through the Recent, are referred to the same species there are some obvious changes in the morphology of the shell through time. However, the Recent examples exhibit so much infraspecific variation there are specimens seen that match the oldest fossils, and so the differences may be due to varying environmental parameters rather than significant changes in the genetic composition. But considering the number of specimens and the number of localities representing different ages, this is not at all certain. For this reason it was decided to figure as many variations as possible and to recognize but one, highly variable, species.

In general, the oldest examples (those from TU 730 and 932) tend to have a more rounded outline, finer ornamentation, only the smallest of spinelets on the siphonal canal, and absolutely no spines on the shoulders. Also, there is no suggestion of varices and the angle at the shoulder is inconspicuous in the aperture. Some specimens (pl. 2, figs. 3 & 4) have two small denticles at the base of the columella but no later examples have more than a single tooth on the inner lip. These oldest specimens are relatively large, one (pl. 2, fig. 1) is 31 mm in height.

By the middle Pliocene "Brighton facies" (TU localities 520, 729, 770, 797, 1000, etc.) the shoulder has become more angulate, as can be seen especially in the aperture. There are still no varices, but the aperture tends to flare at the outer edge, which gives rise to the axial nodes on the whorls. These swollen areas, usually eight or nine per whorl, are the equivalent of varices, as can be seen from the small spines on the siphonal canal. However, there are still no shoulder spines on any specimens. The same is true for the Caloosahatchee examples. It is not until the early Pleistocene Bermont Formation (TU localities 201, 727, 759, etc.) that small open spinelets appear on the shoulders of the whorls.

From the earliest examples the degree of inflation of the body whorl, and the consequent elongation of the shell, is extremely variable (compare pl. 2, figs. 1 and 4, from the same locality). Dall (1890, p. 149) named a variety, *attenuata,* that he stated "shows a considerably more slender shell than the average of this species," giving the dimensions of 29 mm height and 13 mm diameter. The specimen in pl. 3, fig. 8, is a close match for these dimensions and clearly it is well within the range of this variable species. Specimens at the opposite end of the range of variation have been given the name *"Cantharus perplexus"* by Olsson and Harbison (1953, p. 255). As noted by McLean and Emerson (1970, p. 58) that species is based upon robust specimens of *C. ostrearum.* The specimen here figured in pl. 1, fig. 7, is virtually identical to Olsson and Harbison's paratype (1953, pl. 37, fig. 1a).

The nature of the spiral ribbing is equally variable but on the whole the oldest examples tend to have more numerous and less distinct cords. There is also a tendency to have spiral ribs on the subsutural region. Younger specimens have fewer, more pronounced spiral cords, and frequently have the subsutural area almost smooth. (Compare pl. 1, fig. 9c and pl. 4, fig. 11.) As a result of the decrease in number of spiral cords, the younger specimens have correspondingly fewer lirations on the inside of the outer lip. In the early examples there are usually seven or eight lirations, in the younger ones six or seven. These lirations

mark the area *between* the external spiral cords and are one of the few really constant morphological features of the shell. The columellar lip is always smooth, standing slightly erect, glazed, and with a single small denticle that is opposite the anteriormost labral liration, the pair forming a constriction at the entrance into the siphonal canal. The canal is almost straight with the previous terminations forming a marked anterior fasciole that also varies in width.

In the Recent fauna specimens of *C. ostrearum* from deeper water (20 to 25 fathoms) exhibit rather elaborate sculpture. They have short spines at the shoulder, scabrous axial growth lines and small spinelets on the siphonal canal. Three such examples are shown here (pl. 5, figs. 6, 7 & 11), and another is given by McLean and Emerson (1970, plate-fig. 14). The lack of these sculptural features among the fossil specimens suggests that all of the fossils probably lived in water of less than 20 fathoms, which in view of the geology of south Florida is not unexpected.

The type of the genus *Calotrophon, C. turritus* (Dall) from the eastern Pacific, has a very restricted range along the southern end of Baja California, and, is the only species known to occur outside of the western Atlantic. It is markedly different from *C. ostrearum,* being much larger (attaining a maximum height of over 40 mm) and possessing dark color bands on the spiral cords. Nevertheless, there seems no doubt that the two species with such disjunct occurrences are congeneric, the only mystery is the route of travel. Except for the atypical *C. ascensus* from the Pleistocene of Costa Rica, there are no fossil occurrences of *Calotrophon* outside of the Florida area. Somewhere between the middle Miocene and the middle Pliocene this line had to have made its way through the southern Caribbean and up the Pacific coast, leaving no trace of its passage yet known.

CALOTROPHON OSTREARUM CONRADI (Mansfield)

Plate 2, figs. 7-9

Muricidea floridana libertiensis MANSFIELD, 1930, Florida Geol. Surv., Bull. 3, p. 86, pl. 11, fig. 8.

Muricidea floridana conradi MANSFIELD, 1930, Florida Geol. Surv., Bull. 3, p. 87, pl. 12, fig. 3.

Diagnosis: "Shell of moderate size, solid, stronger axially sculptured than spirally, and consists of 5 whorls, tip decollate. Whorls enlarging rather uniformly, constricted below the suture on the later whorls and at the base of the body whorl. Suture more appressed on the earlier than later whorls. Axial sculpture of (9 on the body whorl) prominent rounded ribs separated by rounded-bottomed interspaces equal in width to ribs. Spiral sculpture of rather strong, weakly crenulated, rounded primary lines which are usually intercalated with slightly weaker secondaries. Outer lip, within, strongly marked with 9 entering lirations. Pillar large, end provided with a large perforation." (Mansfield, 1930 – *M. conradi*)

Dimensions of holotype: height 30 mm, diameter 16 mm.

Holotype *(M. conradi):* USNM 370203.

Type locality: Harvey's Creek, Leon County, Florida.

Occurrence: Jackson Bluff Formation, middle Pliocene, Florida.

Figured specimens: Fig. 7, USNM 240651; height 24.4 mm, diameter 13.9 mm; fig. 8, USNM 240652; height 23.4 mm, diameter 11.8 mm; fig. 9, USNM 240653; height 18.0 mm, diameter 10.0 mm; locality TU 60. Other occurrences: TU locality no. 72.

Discussion: Mansfield, in his study of the mollusks of the Choctawhatchee Formation (now Group) of northwestern Florida (1930), described two subspecies of *"Muricidea floridana."* The first, *M. libertiensis,* he stated, "differs from *Muricidea floridana* (Conrad) in having a wider and flatter subsutural area, a less steeply inclined posterior slope, and wider and stronger axials" (1930, p. 87). The second, *M. conradi,* was said to differ from *"M. floridana"* in "having less angulated whorls and a much more constricted pillar at the junction of the body whorl" *(ibid.). M. conradi* supposedly differed from *M. libertiensis* in having a more slender shell and in lacking the secondary spiral sculpture.

Although Mansfield was correct in considering the specimens in the Choctawhatchee as being different from those in the more southern portions of Florida, his lack of specimens did not allow him to recognize the inherent variability of this entire group. In the Tulane Collections there are 42 specimens from Jackson Bluff, and it can be seen that both of his subspecies are the same. The specimens are just a variable as *C. ostrearum* s.s.; however, they are consistently different from that form in having a marked constriction at the base of the body whorl. Some have secondary spirals and some do not.

In view of the geographical separation, as well as this consistently different appearance, the writer feels justified in accepting *C. conradi* as a valid subspecies of *C. ostrearum.* Although *C. libertiensis* has page priority, none of the type lot is complete, and so as first reviser the name *C. conradi* is here selected for the subspecies.

In the Choctawhatchee beds this subspecies occurs with *Peristernia filicata* (Conrad), with which it may be confused at first glance. But *P. filicata* has a strong columellar plait at the base of the pillar and it never forms more than a weak columellar lip, which is completely appressed at the posterior end. The siphonal canal of *P. filicata* is shorter and curved.

CALOTROPHON ASCENSUS
E. H. Vokes, n. sp.
Plate 6, figs. 1, 2

Diagnosis: Shell small, with a protoconch of one and one-half bulbous whorls; five teleoconch whorls in the type material (possibly six in adult specimens). Early ornamentation consisting of ten or eleven small loop-like spines on the first two post-nuclear whorls, decreasing to seven or eight on later whorls. Spiral ornamentation not visible except on body whorl, where three major cords encircle the central portion of the whorl, with two minor cords between the anteriormost major cord and the constriction into the siphonal canal. Only a single poorly developed cord on the siphonal canal. Spiral cords made scabrous by small axial growth lines, and also where the spirals cross the varices, especially on the apertural side of each varix. Suture impressed, subsutural area almost perpendicular to the suture giving a stepped appearance to the spire, which is greatly extended relative to the entire shell. Spire about one-half the total length of the shell. Aperture oval, outer edge crenulated by the three strong spiral cords; inner side of outer lip bearing five or six lirations. Inner lip smooth, polished, appressed against the columellar wall. Siphonal canal short, recurved at the distal end, forming a small fasciole. Shell probably covered in life by a heavy intritacalx, only fragments preserved on fossil specimens.

Dimensions of holotype: height 14.7 mm, diameter 8.7 mm.

Holotype: USNM 240679.

Type locality: TU 954, hill cut immediately behind Standard Fruit Co. box factory, just west of cemetery at Pueblo Nuevo, about 2 km west of Puerto Limon, Costa Rica.

Occurrence: Moín Formation, early Pleistocene, Costa Rica.

Figured specimens: Fig. 1, USNM 240679 (holotype). Fig. 2, USNM 240680 (paratype); height 12.7 mm, diameter 8.0 mm; locality TU 954.

Discussion: In the early Pleistocene beds of the Moín Formation of Costa Rica two small specimens were found, which clearly represent a very different line of *Calotrophon.* Although there seems little doubt that they belong in this genus, they have little resemblance to any of the other known members. The species is small; although the two specimens are probably not adult, as they would be expected ultimately to have six whorls. Even so, they would still be little more than 18 mm in total height. (Compare pl. 6, figs. 1 and 6, both specimens with same number of whorls and same magnification.) The relative spire height is much greater than the *C. ostrearum* line, giving the shell a different outline, with the mid-point of the axis being posterior to the edge of the aperture, whereas in the *C. ostrearum* group it falls well within the aperture. The number of spiral cords is reduced to just three major cords with all others being markedly reduced.

This species has not been noted in the Recent fauna; however, the fauna of the Moín Formation is considered to be relatively deep water and it is anticipated that specimens of *C. ascensus* will soon be recognized as deep dredging continues in the Caribbean.*

CALOTROPHON ANDREWSI
E. H. Vokes, n. sp.
Plate 6, figs. 3-6

Diagnosis: Shell with protoconch of one and one-half bulbous whorls, and six teleoconch whorls in the adult. Early ornamentation invariably worn, but apparently consisting of nine pointed axial nodes; no spiral ornamentation preserved. Axial ornamentation throughout the development of the shell of nine varices, more or less distinct, best evidenced by the spinose processes where the spiral

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*From past experience it is probable that once it has been described it will be recognized in collections. Many of the small species in the Caribbean have been overlooked and only after they have attention called to them are they recognized. A good case in point for this is *Poirieria (Pazinotus) bowdenensis* Vokes, originally based upon a single specimen from the Pleistocene of Jamaica (Vokes, 1970, p. 27). Since then numerous Recent specimens have appeared, which previously had been mis-identified as *"Eupleura" stimpsonii* Dall, another *Pazinotus.* The small shell is apparently not rare at depths of about 100 fathoms.

ornamentation crosses. Spiral ornamentation on body whorl of three to five heavy cords, with a varying number of intercalary threads. No spirals on the subsutural slope. The strength of the cords varying greatly, but usually three more pronounced than the others. Where the cord at the shoulder crosses the varices, long open spines developed; these sometimes curving forward but more usually broken back to simple loops. In addition to the long shoulder spines, smaller spinelets occasionally formed where the other cords cross the varices. On the siphonal canal two additional spiral cords, which always bear spinelets. Aperture triangular, opening into the shoulder spine. Inside the outer lip six to eight lirations, which generally correspond to the intervals between the spiral cords. Inner lip smooth, slightly erect from the columellar wall. Canal moderate in length, straight, anal fasciole of variable width, usually moderately broad in older specimens, lacking in younger ones. Entire shell covered by a heavy, white, massive intritacalx, which masks the overall ornamentation of fine scabrous axial growth lines. Aperture a deep apricot in fresh examples, but quickly fading to pale yellow.

Dimensions of holotype: height 20.0 mm, diameter 11.4 mm.

Holotype: USNM 711111.

Type locality: TU R-44, Isla Mujeres, Quintana Roo, Mexico. Open ocean side (beach collected).

Occurrence: Recent only, southwest Florida to northeast Yucatán.

Figured specimens: Fig. 3, USNM 711111 (holotype). Fig. 4, USNM 711112 (paratype A); height 19.0 mm, diameter 11.4 mm; locality, 80 miles west of Marco, Florida, 28 fms. Fig. 5, USNM 711113 (paratype B); height 17.6 mm, diameter 12.0 mm; locality TU R-44. Fig. 6, AMNH 183197 (paratype C); height 16.0 mm, diameter 10.0 mm; locality, west of Shark River, Florida, 4 fms. Other occurrences: TU locality nos. R-46, R-164; St. John's Pass, Florida, 26 fms. (Steger Coll.); off Egmont Key, Florida, 77 fms. (AMNH 182710).

Discussion: After having documented the extreme variability of *C. ostrearum,* one is hesitant to name a new species of *Calotrophon* that has the same geographical range. It may be that *C. andrewsi* is an ecotype of *C. ostrearum* but the specimens seem sufficiently and consistently different to warrant specific recognition. As noted, the ranges overlap with *C. andrewsi* being confined to the limy banks off southwest Florida and northeast Yucatán. One unfigured paratype (ANSP 303232) in the collections of the Academy of Natural Sciences, Philadelphia, was collected alive in two fathoms depth on sand and grass, off the northwest corner of Isla Mujeres (= TU R-271). We have not taken any specimens at this locality but at nearby TU localities R-44 and R-46, it occurs together with *C. ostrearum* in beach collections.

The differences between *C. ostrearum* and *C. andrewsi* include the much heavier intritacalx, the stronger but less numerous spiral cords, the longer spines and the lack of a labial denticle in *C. andrewsi.* Even the most elaborate deep-water specimens of *C. ostrearum* do not approach the spinosity of *C. andrewsi.* The new species is also smaller, the largest specimen seen is the holotype, which measures only 20 mm, compared with an average of 30 mm for the normal adult of *C. ostrearum.*

C. andrewsi is named in honor of the late Dr. E. Wyllys Andrews of Merida, Yucatán, who, although not a professional malacologist, was perhaps the leading authority on the shells of the Yucatán Peninsula. Unfortunately his untimely death prevented completion of his study of the distribution of species around the peninsula, a task which the author and especially her husband have most willingly inherited.

Genus ATTILIOSA Emerson, 1968

Attiliosa EMERSON, 1968, Veliger, v. 10, no. 4, p. 380.

Type species: *Coralliophila incompta* Berry, by original designation [= *Peristernia nodulosa* A. Adams; see R. C. Bullock, following this paper].

ATTILIOSA STRIATA (Gabb)
Plate 7, figs. 1-9; Plate 8, figs. 1-8
Text figure 2

Muricidea striata GABB, 1873, Amer. Phil. Soc., Trans., (N.S.) v. 15, p. 203.

Muricidea philippiana DALL, 1889, Harvard Mus. Comp. Zool., Bull., v. 18, p. 213 (in part, Key West specimen only); 1889, U.S. Natl. Mus., Bull. 37, p. 120 (Key West specimen only cited).

Muricidea striata Gabb. PILSBRY, 1917, Acad. Nat. Sci. Phila., Proc., v. 73, p. 354, pl. 28, fig. 7 (holotype).

Muricidea philippiana Dall. M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 12 (in part).

Coralliophila philippiana (Dall). M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 33, pl. 20, fig. 20 (Dall's Key West specimen).

Attiliosa philippiana (Dall). S. E. HOERLE, 1970, Tulane Stud. Geol. Paleont., v. 8, no. 2, p. 63 (not of Dall).

Diagnosis: "Spire elevated about equal to the aperture; whorls eight, including the nucleus; angulated. Body whorl sloping nearly straight above, convex below, the angle constricted in advance.

Surface ornamented by seven large ribs on the widest part of the whorls, which become obsolete above and below. Crossing these below the angle are half a dozen linear ribs with broad smooth interspaces. These latter ribs are well developed where they cross the others, but are much smaller in the concave spaces. Mouth subovate, constricted in advance. Incrustation of the inner lip heavy, smooth, and with a projecting free edge; outer lip faintly striate internally. Canal twisted, with a broad imperforate umbilicus." (Gabb, 1873)

Dimensions of holotype: height 12.3 mm, diameter 7.0 mm.

Holotype: ANSP 3249.

Type locality: Santo Domingo, exact locality unknown.

Occurrence: Unknown formation (?) Miocene, Santo Domingo. Agueguexquite Formation, middle Pliocene; Veracruz, Mexico. Pinecrest Beds, middle Pliocene; Caloosahatchee Formation, late Pliocene; Bermont Formation, early Pleistocene; southern Florida. Recent, southern Florida.

Figured specimens: Plate 7, fig. 1, ANSP 3249 (holotype). Fig. 2, USNM 240681; height 23.7 mm, diameter 13.5 mm; locality TU 727. Fig. 3, USNM 240682; height 26.4 mm, diameter 15.7 mm; locality TU 726. Fig. 4, USNM 240683; height 31.9 mm, diameter 18.0 mm; locality TU 991. Fig. 5, USNM 240684; height 16.4 mm, diameter 9.4 mm; locality TU 638. Fig. 6, USNM 240685; height 30.7 mm, diameter 17.3 mm; locality TU 759. Fig. 7, USNM 240686; height 18.9 mm, diameter 11.0 mm; fig. 8, USNM 240687; height 26.0 mm, diameter 17.1 mm; fig. 9, USNM 240688; height 26.3 mm, diameter 15.4 mm; locality TU 201. Plate 8, fig. 1, AMNH 183200; height 14.6 mm, diameter 9.0 mm; fig. 2, AMNH 183200; height 20.0 mm, diameter 12.5 mm; fig. 3, AMNH 183200; height 17.4 mm, diameter 11.0 mm; locality, off Palm Beach County, Florida, 17 fms. Plate 8, fig. 4, FSBC I 11238; height 20.0 mm, diameter 12.5 mm; locality, "Hourglass" Station C, off Tampa Bay, Florida, 20 fms. Fig. 5, AMNH 182709; height 23.6 mm, diameter 12.5 mm; locality, off Sanibel Island, Florida, 30 fms. Fig. 6, AMNH 183199; height 24.8 mm, diameter 13.2 mm; locality, off Briar Reef, Florida. Fig. 7, MCZ 258185; height 17.6 mm, diameter 10.0 mm; locality, Windy Key, Florida. Fig. 8, USNM 34642 ("cotype" of *Muricidea philippiana* Dall); height 17.0 mm, diameter 9.6 mm; locality, Key West, Florida. Other occurrences: TU locality nos. 933, 1177; Recent from Dry Tortugas, Florida, and southwest of Egmont Key, Florida, 25 fms.

Discussion: In beds of an unknown age from an unknown locality, somewhere in

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PLATE 1

Figures Page

1,2. *Poirieria (Panamurex) mauryae* Vokes 103
1. (X 3) USNM 646430 (holotype); height 16.6 mm, diameter 9.0 mm.
Locality: TU 458. Chipola Fm., late lower Miocene.
2. (X 10) USNM 240641; height 12.5 mm, diameter 7.4 mm (protoconch only figured).
Locality: TU 546. Chipola Fm., late lower Miocene.
3,4. *Poirieria (Panamurex) hutchisoni* (Jung) 103
3. (X 3) USNM 645495 (paratype); height 15.6 mm, diameter 9.0 mm.
Locality: USGS 18399, Malajo River, Trinidad. Melajo Clay, (?) late Miocene.
4. (X 10) USNM 645494 (holotype); height 16.6 mm, diameter 9.4 mm (protoconch only figured).
Locality: USGS 21178, Melajo River, Trinidad. Melajo Clay, (?) late Miocene.
5. *Poirieria (Panamurex) phagon* (Gardner) 103
USNM 646431; height 20.0 mm, diameter 11.5 mm.
Locality: TU 91. Oak Grove Sand, (?) late lower Miocene.
(Fig. 5a, X 10; fig. 5b, X 3)
6-9. *Calotrophon ostrearum* (Conrad) 105
6. (X 10) USNM 711115; height 10.6 mm, diameter 5.2 mm (protoconch only figured).
Locality: St. Joseph's Sound, Florida. Recent.
7. (X 2) USNM 240642; height 27.8 mm, diameter 15.2 mm.
Locality: TU 729. Lower Pinecrest Beds, lower Pliocene.
8. (X 2) USNM 240643; height 26.8 mm, diameter 13.0 mm.
Locality: TU 729. Lower Pinecrest Beds, lower Pliocene.
9. USNM 240644; height 27.9 mm, diameter 14.4 mm.
Locality: TU 932. Lower Pinecrest Beds, lower Pliocene.
(Figs. 9a, 9b, X 2; fig. 9c, X10)

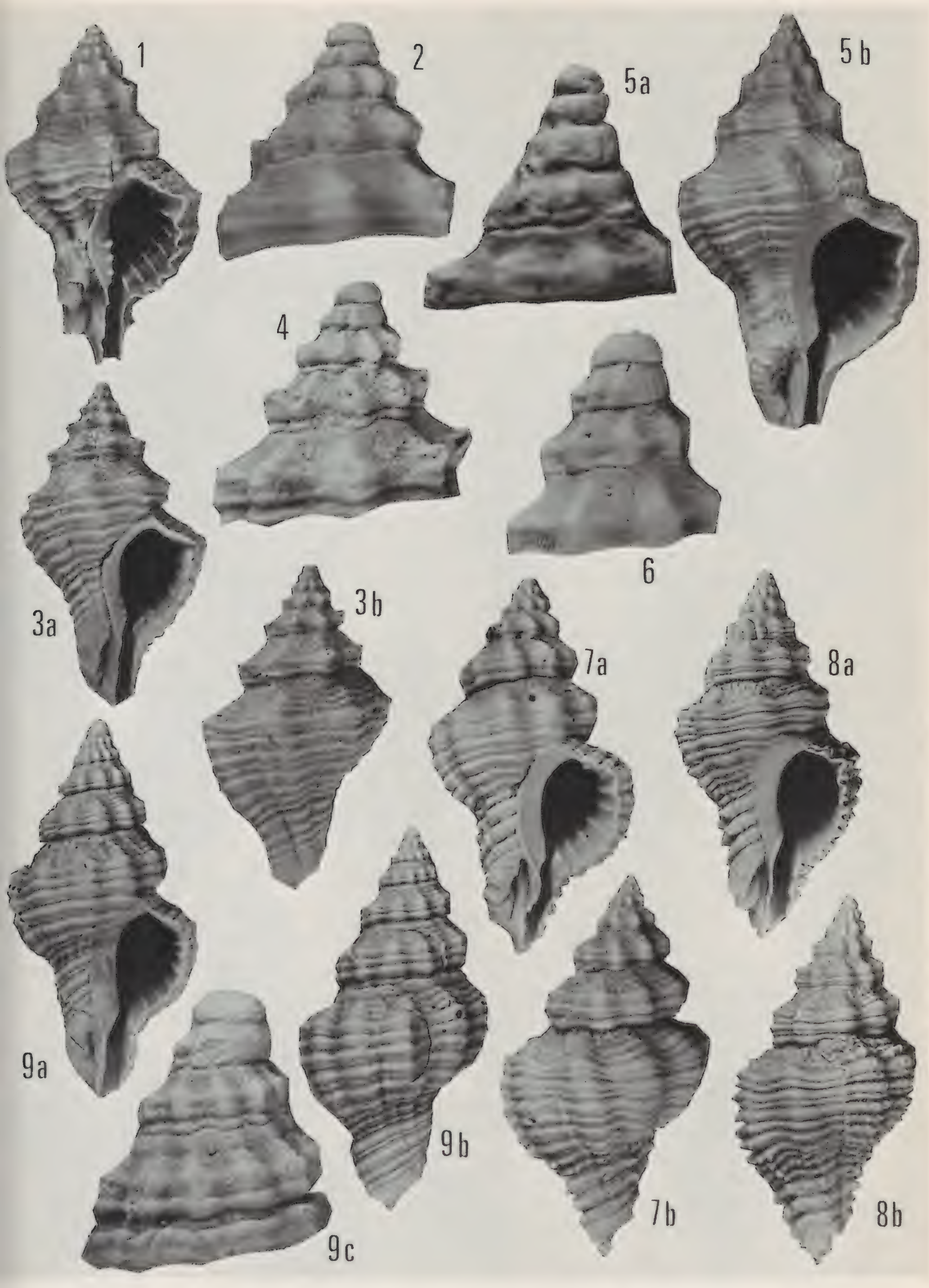

PLATE 1

Santo Domingo, Gabb (1873, p. 203) described a small species as *"Muricidea" striata.* It is unfortunate that the pedigree of this species is so poor as it is the (presumably) oldest known example of a species still living today in the area off southern Florida. No subsequent examples were located in the Dominican Republic by the Maury Expedition of 1916 (Maury, 1917), and so the holotype remains the sole evidence for the early history of the genus *Attiliosa.* The next documented appearance is three worn examples from the middle Pliocene Agueguexquite Formation of southern Veracruz, Mexico (see Akers and Koeppel, 1973, p. 83; also Akers, 1972, p. 28).

The holotype is relatively small, although it is an adult with six post-nuclear whorls, but otherwise it differs little from the Mexican specimens (see pl. 7, figs. 1 and 5). This resemblance is greater than appears at first glance as the tip of the siphonal canal of the holotype is broken and gives the appearance of being shorter than it actually was (see text fig. 2). Other than the smaller size there seems to be no difference between this Dominican fossil and the Recent specimen included by Dall in his *"Muricidea" philippiana* (see pl. 8, fig. 8). When one considers the amazing degree of variability seen in just the specimens figured here, wherein virtually no two are alike, it seems only reasonable to include this small form within the species,

Text figure 2. *Attiliosa striata* (Gabb). ANSP 3249 (holotype); height 12.3 mm, diameter 7.0 mm; locality, Santo Domingo. (X 4)

and it thus gives the entire subsequent line a name.

There is a curious lack of specimens of this species in the Pinecrest Beds of south

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PLATE 2

Figures Page
1-6. *Calotrophon ostrearum* (Conrad) 105
1. USNM 240645; height 32.7 mm, diameter 17.4 mm.
Locality: TU 932. Lower Pinecrest Beds, lower Pliocene.
2. USNM 240646; height 29.6 mm, diameter 14.7 mm.
3. USNM 240647; height 27.2 mm, diameter 13.7 mm.
4. USNM 240648; height 22.3 mm, diameter 10.2 mm.
5. USNM 240649; height 27.2 mm, diameter 13.7 mm.
6. USNM 240650; height 24.1 mm, diameter 11.9 mm.
Locality: TU 730. Lower Pinecrest Beds, lower Pliocene.
7-9. *Calotrophon ostrearum conradi* (Mansfield) 109
7. USNM 240651; height 24.4 mm, diameter 13.9 mm.
8. USNM 240652; height 23.4 mm, diameter 11.8 mm.
9. USNM 240653; height 18.0 mm, diameter 10.0 mm.
Locality: TU 60. Jackson Bluff Fm., lower Pliocene.

(All figures magnified X 2, except fig. 9, which is X 10)

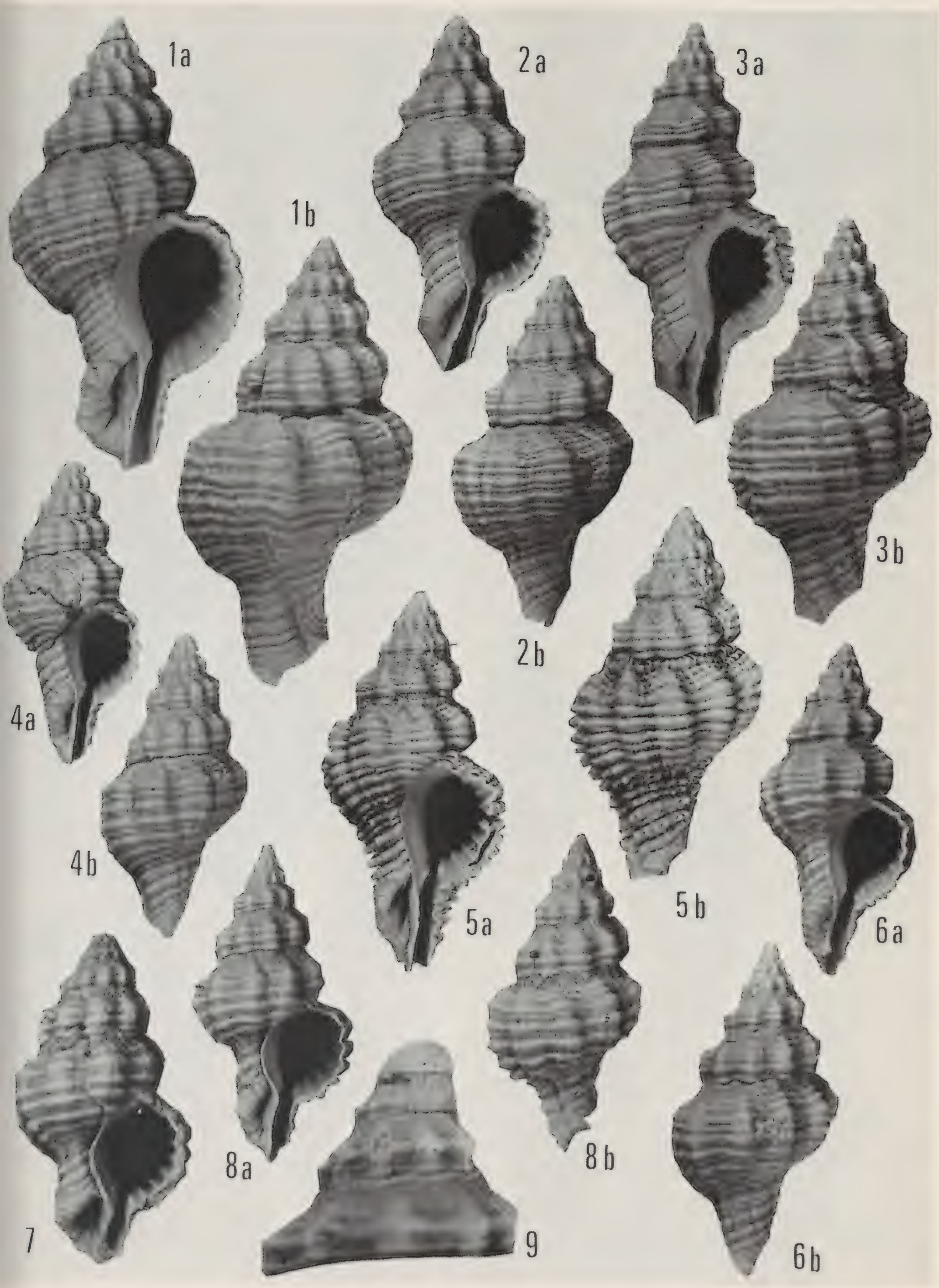

PLATE 2

Florida (a single example from TU 933). Some ecologic change must have occurred at the end of the middle Pliocene so that a more tropical fauna moved into the Florida area. There are several species that do not occur in the Pinecrest but do occur in the Caloosahatchee. In fact, this is the only way one may separate the two "formations" (really time-faunal units). Evidently *A. striata* is one of these, along with *Turbinella scolymoides* Dall and *Liochlamys bulbosa* (Heilprin), two other "guide-fossils" to the Caloosahatchee beds. As the writer discussed in a previous paper (Vokes, 1966, p. 68), *T. scolymoides* does not appear in the Pinecrest Beds either, and this is thought to be due to the fact that the Pinecrest was somewhat cooler in water temperature. Olsson (*in* Olsson and Petit, 1964, p. 517) stated that the Pinecrest fauna has a "decidedly Chesapeake Miocene aspect." The Pinecrest, at that time, was considered to be upper Miocene, as were the correlative beds of the Yorktown Formation, and the writer suggested that the change in temperature between the Miocene and Pliocene (*i.e.*, the Pinecrest and Caloosahatchee) was due to the closing of the Isthmian landbridge, which was thought to take place then. Basically nothing has changed except that the time is now considered to be the end of the middle Pliocene, on both the basis of the land animal migration across this bridge, as well as the planktonic foraminifer and calcareous nannofossil dating of the marine beds (see Akers, 1972 and 1974). The resultant changes in the currents, which created the Gulf Stream, would surely have brought a warmer current across south Florida (then shallow submarine banks) and with it the animals of a somewhat more tropical habitat. The change was probably not great – a few degrees at most – but enough to modify the fauna so that it is recognizably different. It would have been the same slight temperature shift that moved mangroves and *Calotrophon ostrearum* into North Carolina during this same time interval.

Certainly the genus was living somewhere in the Caribbean area, and it is only lack of outcrops of the appropriate age that prevents our having a better knowledge of the sequence. Unfortunately the group has no record in the more southern areas such as Venezuela or Colombia where we might hope to fill in the gap. But it seems obvious that the group crossed through the Isthmian passage sometime before the landbridge sealed off the route, for in the Recent Pacific fauna are two species that are closely related to the Atlantic fossil form. The type species of the genus, *A. incompta* (Berry), is a smooth form, more akin to the Recent Atlantic *A. philippiana* than to the ornamented *A. striata.* The more heavily ornamented Pliocene specimens of *A. striata*

PLATE 3

Figures Page

1-9. *Calotrophon ostrearum* (Conrad) 105

1. USNM 240654; height 26.2 mm, diameter 12.5 mm.
2. USNM 240655; height 24.4 mm, diameter 12.8 mm.
3. USNM 240656; height 20.2 mm, diameter 11.7 mm.
   Locality: TU 1000. Upper Pinecrest Beds, middle Pliocene.
4. USNM 240657; height 24.7 mm, diameter 14.0 mm.
5. USNM 240658; height 24.9 mm, diameter 13.2 mm.
6. USNM 240659; height 27.4 mm, diameter 13.2 mm.
7. USNM 240660; height 24.6 mm, diameter 12.0 mm.
   Locality: TU 519. Caloosahatchee Fm., upper Pliocene.
8. USNM 240661; height 31.5 mm, diameter 15.0 mm.
   Locality: TU 539B. Caloosahatchee Fm., upper Pliocene.
9. USNM 647695; height 20.0 mm, diameter 10.7 mm.
   Locality: Fairmont, North Carolina. Duplin Fm., (?) middle Pliocene.

(All figures magnified X 2)

PLATE 3

(e.g., pl. 7, figs. 4, 7, & 9) bear a strong resemblance to the Recent eastern Pacific species *"Murex" carduus* Broderip, 1832 (figured by Keen, 1971, fig. 1041).

This species was referred to the trophonine subgenus *Acanthotrophon* Hertlein and Strong, 1951, by Berry (1969, p. 162) together with his then new species *A. sentus* (see Keen, 1971, fig. 1042). When one examines *A. sorensoni* Hertlein and Strong, 1951, type of *Acanthotrophon,* it gives added strength to the writer's conviction that the subfamily "Trophoninae" is polyphyletic. There is a seeming line of morphological development from *Attiliosa carduus* (the latin word *carduus* – a thistle – is a noun and does not change to agree with the feminine *Attiliosa*), which is heavily ornamented, to *Acanthotrophon sentus,* moderately ornamented, to *Acanthotrophon sorensoni,* which is barely ornamented. The manner of forming the shoulder spines is identical in all three. But *A. carduus* has the large umbilicus and labial denticles of *Attiliosa* and the other two lack these features. *Acanthotrophon sorensoni* has every appearance of being a true *Trophon* and has the thin, chalky shell of a deep-water species (the holotype is from 60 fms). In addition, information provided by Radwin and D'Attilio *(in litt.)* shows that the radulae are totally different. Although *Acanthotrophon* is muricine, it is very unlike *Attiliosa.*

The writer is of the opinion that the boreal species of Trophoninae, those which have a muricoid operculum,* are derived

*As opposed to the southern forms with a purpuroid operculum, which are probably derived from a *Urosalpinx*-like ancestor. The type of *Trophon, T. geversianus* (Pallas), is of this group and hence the true Trophoninae are also. It may well be that many of the northern members, such as *Boreotrophon, Pagodula, Acanthotrophon,* etc., should be placed in the Muricinae. Certainly the type species of *Actinotrophon, T. actinophora* Dall, is a *Poirieria* s.s. (see Bayer, 1971, p. 157). The radulae of these northern forms differ very little

PLATE 4

Figures — Page

1-11. *Calotrophon ostrearum* (Conrad) 105

1. USNM 240662; height 21.5 mm, diameter 10.4 mm.
   Locality: TU 726. Caloosahatchee Fm., upper Pliocene.
2. USNM 240663; height 21.4 mm, diameter 10.8 mm.
   Locality: TU 726. Caloosahatchee Fm., upper Pliocene.
3. USNM 240664; height 20.6 mm, diameter 10.4 mm.
   Locality: TU 767. Caloosahatchee Fm., upper Pliocene.
4. USNM 240665; height 22.3 mm, diameter 11.1 mm.
   Locality: TU 767. Caloosahatchee Fm., upper Pliocene.
5. USNM 240666; height 24.0 mm, diameter 12.0 mm.
   Locality: TU 727. Bermont Fm., lower Pleistocene.
6. USNM 240667; height 25.3 mm, diameter 13.0 mm.
   Locality: TU 727. Bermont Fm., lower Pleistocene.
7. USNM 240668; height 23.5 mm, diameter 12.0 mm.
   Locality: TU 978. Bermont Fm., lower Pleistocene.
8. USNM 240669; height 28.3 mm, diameter 14.8 mm.
   Locality: TU 759. Bermont Fm., lower Pleistocene.
9. USNM 240670; height 35.3 mm, diameter 17.0 mm.
   Locality: TU 978. Bermont Fm., lower Pleistocene.
10. USNM 240671; height 21.5 mm, diameter 11.5 mm.
    Locality: TU 978. Bermont Fm., lower Pleistocene.
11. USNM 240672; height 17.3 mm, diameter 9.4 mm (protoconch only figured).
    Locality: TU 201. Bermont Fm., lower Pleistocene.

(All figures magnified X 2, except fig. 11, which is X 10)

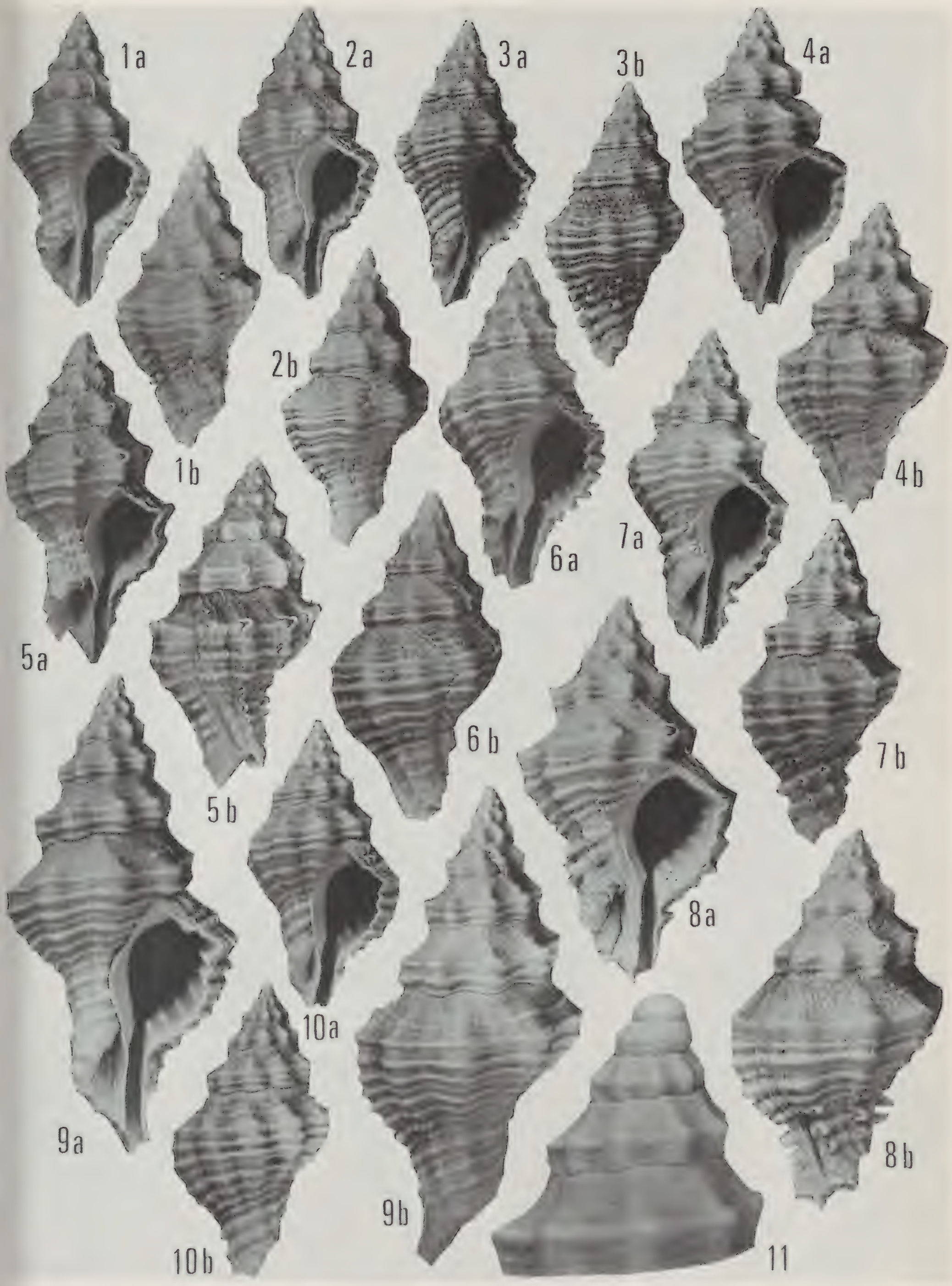

PLATE 4

from a *Poirieria*-like ancestor. This also explains the problems with such intermediate forms as the Japanese species referred by some to *Nipponotrophon* Kuroda and Habe, 1971 (type species: *Boreotrophon echinus* Dall) and to *Poirieria* by the writer. Inasmuch as *Attiliosa* is also believed to have come from a *Poirieria* ancestor, the resemblances between *Attiliosa* and the trophonine species would seem to be parallelism.

ATTILIOSA PHILIPPIANA (Dall)
Plate 8, figs. 12-14

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from the normal muricine one, whereas that of *T. geversianus* is more like that of the Ocenebrinae (G. E. Radwin, personal communication). However, the laminated varices, considered "typical" of the Trophoninae appear in both groups and must represent convergence rather than close relationship. The same sort of situation is seen in *Pterynotus* and *Pteropurpura,* two extremely similar, but distantly related, genera.

Muricidea philippiana DALL, 1889, Harvard Mus. Comp. Zool., Bull., v. 18, p. 213 (in part, Cabo Catoche specimen only); 1902, U.S. Natl. Mus., Proc., v. 24, p. 504, pl. 29, fig. 5.

Not *Muricidea philippiana* Dall. DALL, 1889, U.S. Natl. Mus., Bull. 37, p. 120 [= *A. striata* (Gabb)].

Muricidea philippiana Dall. JOHNSON, 1934, Boston Soc. Nat. Hist., Proc., v. 40, p. 116 (in part only).

Muricidea philippiana Dall. M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 12 (in part only).

Not *Coralliophila philippiana* (Dall). M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 33, pl. 20, fig. 20 [= *A. striata* (Gabb)].

Not *Attiliosa philippiana* (Dall). S. E. HOERLE, 1970, Tulane Stud. Geol. Paleont., v. 8, no. 2, p. 63 [= *A. striata* (Gabb)].

[Calotrophon (Attiliosa)] philippiana (Dall). E. H. VOKES, 1971, Bulls. Amer. Paleontology, v. 61, no. 278, p. 81 (in part only).

Calotrophon (Attiliosa) philippiana (Dall). ABBOTT, 1974, Amer. Seashells, 2nd Ed., p. 188 (? in part only).

Diagnosis: "Shell short, acutely fusiform, solid, with about five whorls; spire acute, suture flexu-

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PLATE 5

Figures — Page

1-11. *Calotrophon ostrearum* (Conrad) 105

1. USNM 240673; height 24.6 mm, diameter 11.7 mm.
   Locality: TU 580. Bermont Fm., lower Pleistocene.
2. USNM 240674; height 22.0 mm, diameter 11.2 mm.
   Locality: TU 580. Bermont Fm., lower Pleistocene.
3. USNM 240675; height 24.1 mm, diameter 12.5 mm.
   Locality: TU 777. Anastasia Fm., upper Plesitocene.
4. USNM 240676; height 20.0 mm, diameter 10.7 mm.
   Locality: TU 529A. Ft. Thompson Fm., upper Pleistocene.
5. USNM 240677; height 19.0 mm, diameter 10.1 mm.
   Locality: TU 529A. Ft. Thompson Fm., upper Pleistocene.
6. USNM 240678; height 25.7 mm, diameter 13.7 mm.
   Locality: TU 977. Post-Pleistocene.
7. AMNH 100637A; height 27.9 mm, diameter 14.4 mm.
   Locality: Off Egmont Key, Florida; 25 fms. Recent.
8. USNM 711108; height 22.4 mm, diameter 11.6 mm.
   Locality: TU R-9. Recent.
9. USNM 711109; height 25.3 mm, diameter 12.8 mm.
   Locality: TU R-220. Recent.
10. USNM 711110; height 24.4 mm, diameter 12.3 mm.
    Locality: TU R-220. Recent.
11. FSBC I 11240; height 23.2 mm, diameter 14.0 mm.
    Locality: "Hourglass" Station K, off Ft. Myers, Florida; 20 fms. Recent.

(All figures magnified X 2)

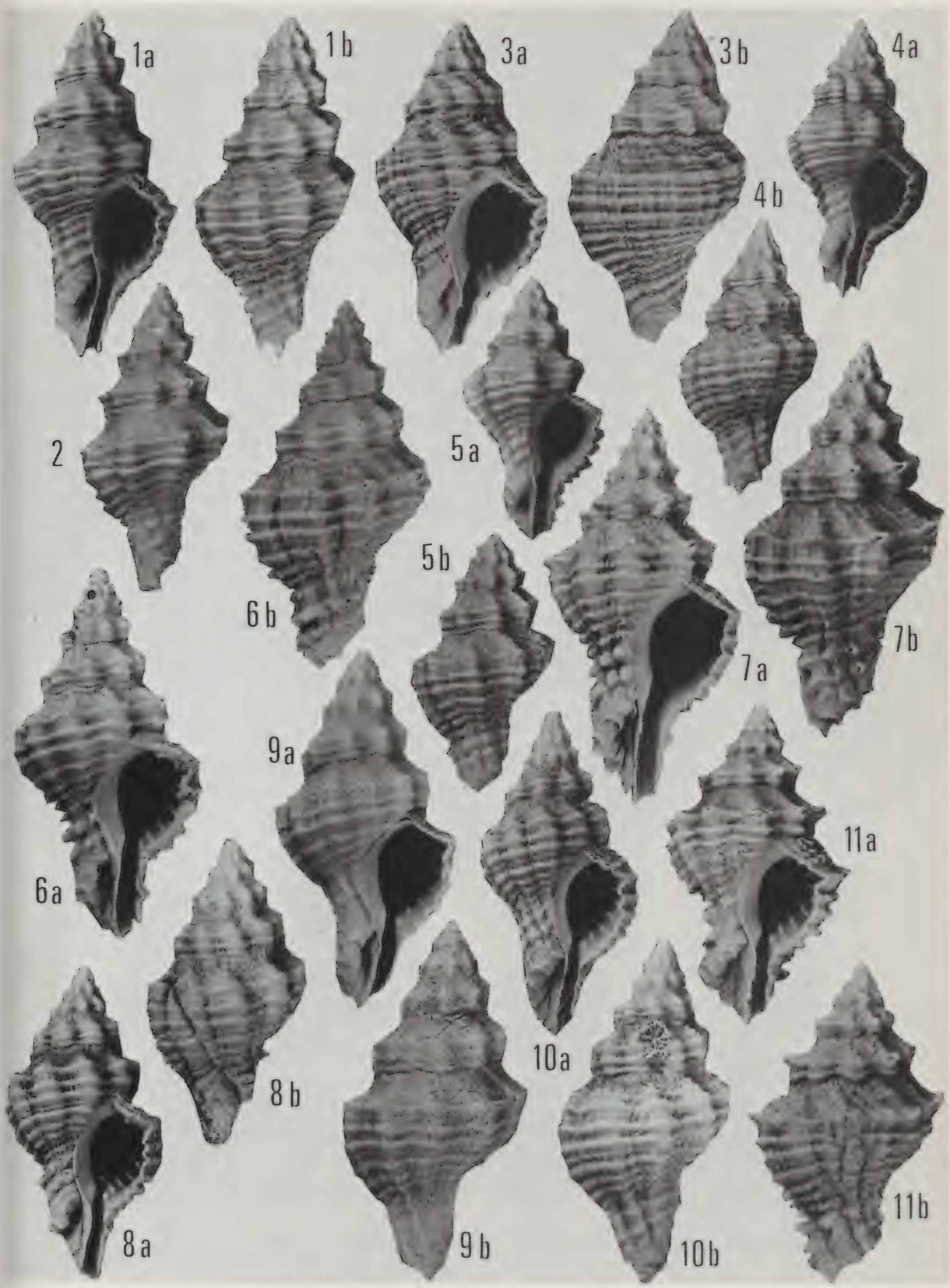

PLATE 5

ous, appressed; slope of the spire nearly flat, the turns being flattened or even slightly excavated above the periphery; transverse sculpture of lines of growth, and of (on the last whorl nine) peripheral undulations or ribs with about equal interspaces; these are almost confined to the periphery; in one specimen these are crossed by three or four about equidistant spiral ridges, faint, becoming prominent and keeled or nodulous on the ribs; this one has also two strong ridges on the canal, and is pure white; another specimen has only faint spiral striae on the canal, the periphery is smooth, the ribs lumpy, the color white with spiral brown lines toward the periphery; in still another the posterior row of nodulations becomes short, sharp, and spinous, the revolving threads seem more numerous on the base; canal short, rapidly tapering, open, pointed; a well marked siphonal fasciole is normal, one hardly shows it, another has it funicular; aperture elongate oval, outer lip with 5-7 strong lirae within; margin simple, acute; throat porcelain-white with a tendency to rosy or purple; columella smooth with a dash of rose or purple in some specimens, and two or three faint granulations, in the perfectly adult, near its anterior edge." (Dall, 1889).

Dimensions of lectotype: height 14.9 mm, diameter 8.8 mm.

Lectotype: USNM 93337 (here designated).

Type locality: U.S. Fish Comm. Station 2362, off Cabo Catoche, Quintana Roo, Mexico, 25 fms.

Occurrence: Recent only, southern Florida and northern Yucatán.

Figured specimens: Fig. 12, USNM 93337 (lectotype). Fig. 13, FSBC I 11242; height 14.4 mm, diameter 8.0 mm; locality, about 35 miles north of Cabo Catoche, Mexico, 20 fms. Fig. 14, AMNH 183198; height 17.0 mm, diameter 10.0; locality, off Palm Beach County, Florida, 16 fms.

Discussion: Dall (1889, p. 213) admitted when he described this species that it had puzzled him "for some time." He is not alone, for this small, rare species has been an enigma to all who have followed him, and the present writer is by no means certain of the present resolution of the problem. It may well be that *A. philippiana* is no more than a smooth ecotype of the ornamented *A. striata.* The specimens of *Attiliosa* are extremely variable, and with as few examples as there are available in collections, the range of variation is not well established.

In the type lot of *A. philippiana* there are two specimens, one from Cabo Catoche, Mexico (USNM 93337), and the second from Key West, Florida (USNM 34642). It is the Cabo Catoche specimen that Dall subsequently figured (1902, pl. 29, fig. 5). The two specimens do not appear to belong to the same species. The unfigured Key West specimen clearly is *A. striata* and, in part, is the shell described by Dall in his original description. The dimensions cited there ("Max. lon. of shell, 17.4; of last whorl, 12.4; of aperture, 10.0 max. lat. of aperture, 4.5; of shell, 10.5.") refer to this specimen as do the portions of the description concerning spiral ridges and ornamentation. However, as the figured specimen is the one which has been taken by subsequent workers to be the standard for the species (and

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PLATE 6

Figures Page

1,2. *Calotrophon ascensus* E. H. Vokes, n. sp. 110
1. USNM 240679 (holotype); height 14.7 mm, diameter 8.7 mm.
2. USNM 240680 (paratype); height 12.7 mm, diameter 8.0 mm.
Locality: TU 954. Moín Fm., lower Pleistocene.
3-6. *Calotrophon andrewsi* E. H. Vokes, n. sp. 110
3. USNM 711111 (holotype); height 20.0 mm, diameter 11.4 mm.
Locality: TU R-44. Recent.
4. USNM 711112 (paratype A); height 19.0 mm, diameter 11.4 mm.
Locality: 80 miles west of Marco, Florida, 28 fms. Recent.
5. USNM 711113 (paratype B); height 17.6 mm, diameter 12.0 mm.
Locality: TU R-44. Recent
6. AMNH 183197 (paratype C); height 16.0 mm, diameter 10.0 mm.
Locality: west of Shark River, Florida, 4 fms. Recent.

(All figures magnified X 3, except figs. 2c and 6c which are X 10)

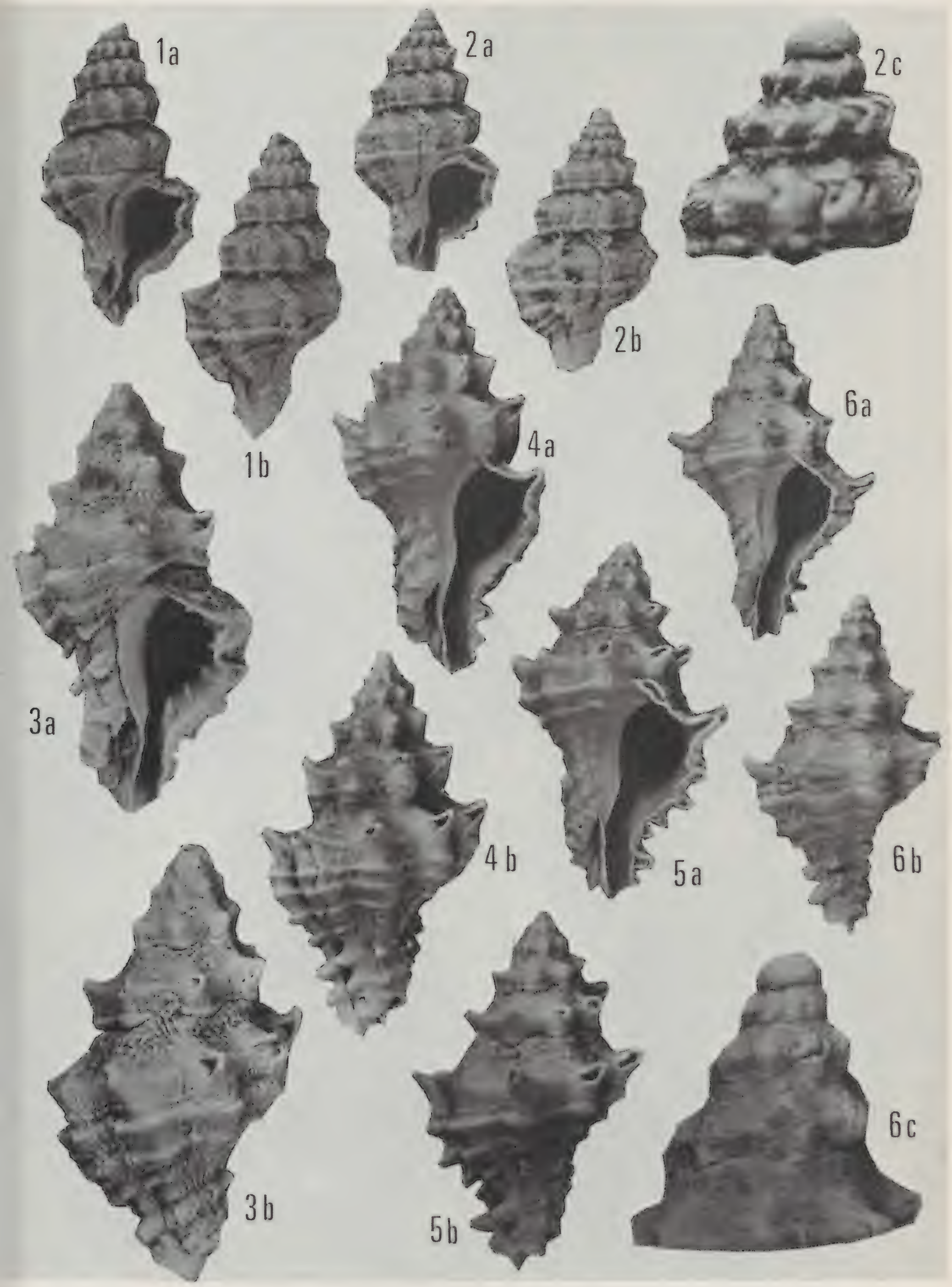

PLATE 6

inasmuch as there is certainly nothing to be gained by placing the name *philippiana* in synonymy and creating another for the form) the figured specimen is here selected as lectotype.

The range of *A. philippiana* seems confined to the southern Florida, northern Yucatán area. The range is essentially identical to that of *A. striata* and, in fact, the two forms have been taken together off Palm Beach County, Florida (see pl. 8, figs. 1-3, 14).

ATTILIOSA ALDRIDGEI
(Nowell-Usticke)

Plate 8, figs. 9-11

Vasum aldridgei NOWELL-USTICKE, 1969, Suppl. List New Shells St. Croix, p. 18, pl. 4, no. 834.
Attiliosa aldridgei (Nowell-Usticke). NOWELL-USTICKE, 1971, Suppl. Listing New Shells, Revised Edition, p. 11, pl. 2, no. 680.

Diagnosis: "A smallish, solid, pointed, whitish shell of about 7 whorls, with concavely sloping shoulders, and 6 or 7 strong, swollen rounded varical ribs on the body whorl. On the spire just above the suture, the top of each rib is ornamented with 2 short, raised, horizontal orange lines; on the body whorl, in addition to these 2 raised horizontal orange lines on the periphery, there are 2 more short horizontal lines below the middle, and a weak orange patch at the base.

"The body is covered with faint spiral ribbing. There is a smooth white callus on the parietal wall, with two weak columella folds low down. The mouth is smoothly rounded and has 6 teeth inside the outer lip. The siphonal canal is straight, and the base recurved." (Nowell-Usticke, 1971)

Dimensions of holotype: height 30 mm, diameter 20 mm (*fide* Nowell-Usticke).

Holotype: In collection of Mr. G. Nowell-Usticke, St. Croix, U.S. Virgin Islands.

Type locality: Rat Island, Antigua, B.W.I.

Occurrence: Recent only, western Atlantic, from Bahamas and Belice (British Honduras) to Lesser Antilles and Panamá.

Figured specimens: Fig. 9, AMNH 168901 (paratype); height 22.4 mm, diameter 14.0 mm; locality, same as holotype. Fig. 10, USNM 711114; height 10.4 mm, diameter 6.0 mm; locality TU R-98. Fig. 11, FSBC I 11237; height 28.8 mm, diameter 18.3 mm; locality, Andros Island, Bahamas, reef top.

Discussion: Attiliosa aldridgei is apparently not a rare shell, but because of the normal appearance, completely encrusted with coralline algae (see pl. 8, fig. 11), it is not well represented in collections. This protective camouflage serves a reef or coralline dwelling animal, such as this is, very well. From the material available it appears that the species is found throughout the tropical western Atlantic, exclusive of the Gulf of Mexico area. The known specimens are from Belice (ANSP 281825), Puerto Rico (AMNH

PLATE 7

Figures — Page

1-9. *Attiliosa striata* (Gabb) 111

1. ANSP 3249 (holotype); height 12.3 mm, diameter 7.0 mm.
Locality: Santo Domingo. Unknown formation.
2. USNM 240681; height 23.7 mm, diameter 13.5 mm.
Locality: TU 727. Bermont Fm., lower Pleistocene.
3. USNM 240682; height 26.4 mm, diameter 15.7 mm.
Locality: TU 726. Caloosahatchee Fm., upper Pliocene.
4. USNM 240683; height 31.9 mm, diameter 18.0 mm.
Locality: TU 991. Caloosahatchee Fm., upper Pliocene.
5. USNM 240684; height 16.4 mm, diameter 9.4 mm.
Locality: TU 638. Agueguexquite Fm., middle Pliocene.
6. USNM 240685; height 30.7 mm, diameter 17.3 mm.
Locality: TU 759. Bermont Fm., lower Pleistocene.

7. USNM 240686; height 18.9 mm, diameter 11.0 mm.
8. USNM 240687; height 26.0 mm, diameter 17.1 mm.
9. USNM 240688; height 26.3 mm, diameter 15.4 mm.
Locality: TU 201. Bermont Fm., lower Pleistocene.

(All figures magnified X 2)

PLATE 7

182494), Trinidad (MCZ 274319), the Bahamas, Antigua, and off Cape San Blas, Panamá.

This is a heavy, robust species, larger than the other Atlantic living representatives of *Attiliosa.* It is comparable to the Pacific *A. incompta* (Berry), which is also commonly covered with lime (see Emerson, 1968, plate 53, figs. 4, 5). One of the most diagnostic features, and one of the few easily observed on the encrusted shells, is the two or three dark brown spots on the edge of the outer lip, which are a continuation of the orange spiral color bands on the outside. It may also be distinguished from other Recent species of *Attiliosa* by the relatively heavy spiral ornamentation, consisting of three strong cords and numerous finer threads.

Bullock (1969, p. 76) stated that *Vasum aldridgei* was not a new species, but rather a synonym of *"Muricopsis" philippiana* Dall. This opinion was, however, based upon a misconception of the identity of *A. philippiana* (Bullock, personal communication). The two forms have generic similarities but are by no means synonymous.

V. LOCALITY DATA

The following are Tulane University locality numbers:

60. Jackson Bluff Fm., borrow pits at Jackson Bluff, Ochlockonee River (NW ¼ Sec. 21, T1S, R4W), Leon Co., Florida.
72. Jackson Bluff Fm., Alum Bluff (upper beds), Apalachicola River (NE ¼ Sec. 24, T1N, R8W), Liberty Co., Florida.

PLATE 8

Figures Page

1-8. *Attiliosa striata* (Gabb) 111

1. (X 2) AMNH 183200; height 14.6 mm, diameter 9.0 mm.
2. (X 2) AMNH 183200; height 20.0 mm, diameter 12.5 mm.
3. (X 2) AMNH 183200; height 17.4 mm, diameter 11.0 mm.
   Locality: Off Palm Beach Co., Florida; 17 fms. Recent.
4. (X 2) FSBC I 11238; height 20.0 mm, diameter 12.5 mm.
   Locality: "Hourglass" Station C, off Tampa Bay, Florida; 20 fms. Recent.
5. (X 2) AMNH 182709; height 23.6 mm, diameter 12.5 mm.
   Locality: southwest of Sanibel, Florida; 30 fms. Recent.
6. (X 2) AMNH 183199; height 24.8 mm, diameter 13.2 mm.
   Locality: Off Briar Reef, Florida. Recent.
7. (X 2) MCZ 258185; height 17.6 mm, diameter 10.0 mm.
   Locality: Windy Key, Florida. Recent.
8. (X 3) USNM 34642 (as *Muricidea philippiana* Dall); height 17.0 mm. diameter 9.6 mm.
   Locality: Key West, Florida; on coral, low water. Recent.

9-11. *Attiliosa aldridgei* (Nowell-Usticke) 124

9. (X 2) AMNH 168901 (paratype); height 22.4 mm, diameter 14.0 mm.
   Locality: Rat Island, Antigua, B.W.I. Recent.
10. (X 4) USNM 711114; height 10.6 mm, diameter 6.0 mm.
    Locality: TU R-98. Recent.
11. (X 1¼) FSBC I 11237; height 28.7 mm, diameter 18.2 mm.
    Locality: Andros Island, Bahamas; on coral, low water. Recent.

12-14. *Attiliosa philippiana* (Dall) 120

12. (X 3) USNM 93337 (lectotype); height 14.9 mm, diameter 8.8 mm.
    Locality: Cabo Catoche, Quintana Roo, Mexico; 25 fms. Recent.
13. (X 3) FSBC I 11242; height 14.4 mm, diameter 8.0 mm.
    Locality: about 35 miles north of Cabo Catoche, Mexico; 20 fms. Recent.
14. (X 2) AMNH 183198; height 17.0 mm, diameter 10.0 mm.
    Locality: same as figs. 1-3.

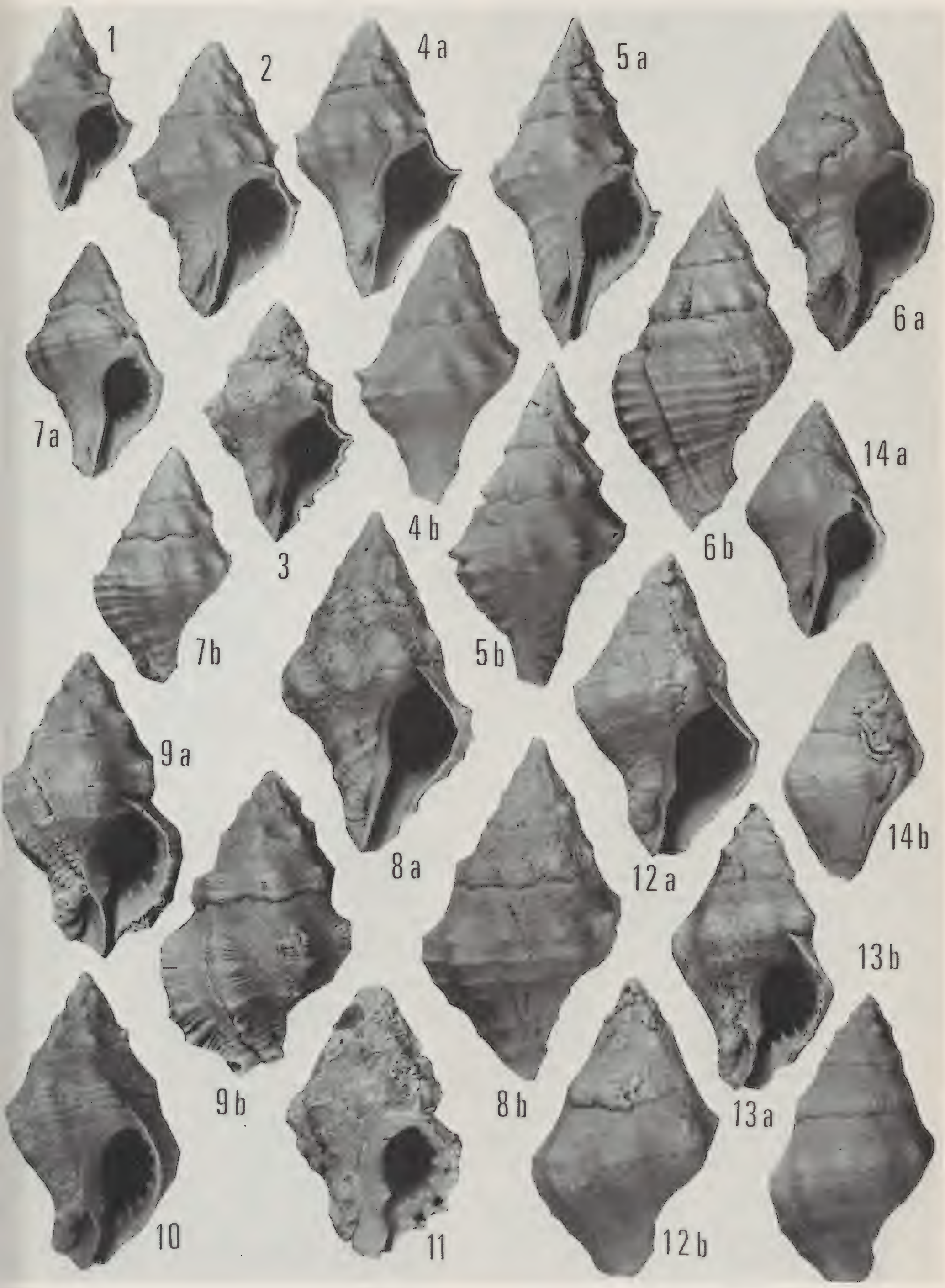

PLATE 8

79. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks north and south side of Caloosahatchee River, at Ortona Lock (Sec. 27, T42S, R30E), Glades Co., Florida.
91. Oak Grove Sand, type locality, west bank of Yellow River, about 100 yards below bridge at Oak Grove (NE ¼ Sec. 20, T5N, R23W), Okaloosa Co., Florida.
200. Pinecrest Beds, borrow pits about one mile southwest of Acline (Sec. 29, T41S, R23E), Charlotte Co., Florida.
201. Bermont Fm., spoil banks at pit just south of Belle Glade (at Belle Glade Camp), Palm Beach Co., Florida.
202. Caloosahatchee Fm., south bank of Caloosahatchee River, about two miles west of La Belle (SE ¼ Sec. 12, T43S, R28E), Hendry Co., Florida.
203. Caloosahatchee Fm., north bank of Caloosahatchee River, about two miles east of Fort Denaud (SW ¼ Sec. 11, T43S, R28E), Hendry Co., Florida.
283. Pinecrest Beds and Bermont Fm. mixed, spoil banks on cross-canal 1.3 miles southwest of Port Charlotte Railroad Station (formerly Murdock), on Florida Highway 771 (Sec. 12, T40S, R21E), Charlotte Co., Florida.
458. Chipola Fm., east bank of Chipola River, above Farley Creek (SW ¼ Sec. 20, T1N, R9W), Calhoun Co., Florida.
519. Caloosahatchee Fm., Harney Pond Canal spoil banks, at Florida Highway 78, northwest side of Lake Okeechobee (NW ¼ Sec. 18, T40S, R33E), Glades Co., Florida.
520. Pinecrest Beds, spoil banks, canal 0.9 mile east of Brighton on Florida Highway 70 (Sec. 25, T37S, R32E), Highlands Co., Florida.
522. Pinecrest Beds, Harney Pond Canal spoil banks, three miles northwest of Florida Highway 78 (NE ¼ Sec. 36, T39S, R32E), Glades Co., Florida.
523. Pinecrest Beds, Harney Pond Canal spoil banks, six miles northwest of Florida Highway 78, Brighton Indian Reservation (NW ¼ Sec. 22, T39S, R32E), Glades Co., Florida.
525. Pinecrest Beds, U.S. Highway 41, at "Forty-mile Bend," Dade Co., Florida.
527. Caloosahatchee Fm., north shore Lake Okeechobee, Pumping Station no. 127 (NE ¼ Sec. 35, T39S, R33E), Glades Co., Florida.
529a. Fort Thompson Fm., same as TU 529b, but stratigraphically higher.
529b. Caloosahatchee Fm., north bank of Caloosahatchee River, about two miles west of La Belle (SE ¼ Sec. 12, T43S, R28E), Hendry Co., Florida.
532. Pinecrest Beds, spoil banks 1¾ miles south of Florida Highway 771, on canal 1.3 miles southwest of Port Charlotte Railroad Station (formerly Murdock) (SE ¼ Sec. 24, T40S, R21E), Charlotte Co., Florida.
536. Caloosahatchee Fm., south bank of Caloosahatchee River about one mile east of La Belle (Sec. 3 & 4, T43S, R29E), Hendry Co., Florida. (Designated as type locality of the Caloosahatchee Formation by Olsson *in* Olsson and Petit, 1964, p. 519.)
539a. Bermont Fm., Shell Creek (upper beds), about eight miles east of Cleveland (Sec. 30, T40S, R25E), Charlotte Co., Florida. (Designated as type locality of the Bermont Formation by DuBar, 1974, p. 221.)
539b. Caloosahatchee Fm., Shell Creek (lower beds), about eight miles east of Cleveland (Sec. 30, T40S, R52E), Charlotte Co., Florida.
540. Pinecrest Beds, Miami Canal spoil banks, one to three miles south of pumping station at Palm Beach county line, Broward Co., Florida.
546. Chipola Fm., Ten Mile Creek, about 1¾ miles west of Chipola River (NE ¼ Sec. 12, T1N, R10W), Calhoun Co., Florida (= USGS 2212, "one mile west of Bailey's Ferry").
579. Caloosahatchee Fm., Miami Canal spoil banks, four miles north of pumping station at Broward county line, Palm Beach Co., Florida.
580. Bermont Fm., North New River Canal spoil banks, one mile south of South Bay, Palm Beach Co., Florida.
582. Bermont Fm., "Rim Ditch" spoil banks, just north of Florida-East Coast Railroad crossing (Sec. 29, T36S, R39E), St. Lucie Co., Florida.
583. Caloosahatchee Fm., Miami Canal spoil banks, seven miles north of pumping station at Broward county line, Palm Beach Co., Florida.
638. Agueguexquite Fm., roadcut and quarry on Mexico Highway 180, 14 miles east of junction with side road into Coatzacoalcos, Veracruz, Mexico.
725. Bermont Fm., North New River Canal spoil banks, three miles south of South Bay, at Okeelanta, Palm Beach Co., Florida.
726. Caloosahatchee Fm., Hendry County rock pit, ½ mile north of Florida Highway 80, three miles west of La Belle (SE ¼ Sec. 14, T43S, R28E), Hendry Co., Florida.
727. Bermont Fm., borrow pits 2.2 miles east of U.S. Highway 27, 15 miles south of South Bay, Palm Beach Co., Florida.
728. Pinecrest Beds, spoil banks on west side of Kissimmee Canal and east side of Kissimmee River, just across from U.S. Corps of Engineers Structure 65-D (Sec. 33, T36S, R33E), Okeechobee Co., Florida.
729. Pinecrest Beds, spoil banks on west side of Kissimmee Canal and east side of Kissimmee River, approximately ½ mile south of U.S. Corps of Engineers Structure 65-D (S ½ Sec. 33, T36S, R33E), Okeechobee Co., Florida.
730. Pinecrest Beds, embankment of Seaboard Airline Railroad, just west of Kissimmee River, (NW ¼ Sec. 20, T36S, R33E), Highlands Co., Florida.

731. Bermont Fm., West Palm Beach Canal spoil banks, at Twenty Mile Bend Recreation area just east of junction of U.S. Highways 441 and 98, Palm Beach Co., Florida.
733. Bermont Fm., North New River Canal spoil banks, one mile north of Florida Highway 80, at South Bay, Palm Beach Co., Florida.
736. Pinecrest Beds and Caloosahatchee Fm. mixed, spoil banks on south side of Florida Highway 70 and east side of Kissimmee River, Okeechobee Co., Florida.
740. Pinecrest Beds, levee fill, L-28, 3.6 miles west and 2.6 miles south of pumping station on Miami Canal at Broward-Palm Beach county line, Broward Co., Florida.
745. Caloosahatchee Fm., Miami Canal spoil banks, 10.8 miles north of pumping station at Broward county line, Palm Beach Co., Florida.
746. Bermont Fm., North New River Canal spoil banks, 5.3 miles north of pumping station at Broward county line on U.S. Highway 27, Palm Beach Co., Florida.
747. Bermont Fm., North New River Canal spoil banks, two miles south of South Bay, Palm Beach Co., Florida.
750. Bermont Fm., spoil banks cross-canal 3.1 miles south of Lake Harbor on Miami Canal, Palm Beach Co., Florida.
752. Pinecrest Beds, spoil banks on south side of Canal 41-C ("Slough Ditch") at crossing of country road, 4.3 miles east of Brighton and 1.4 miles south of Florida Highway 70 (SE ¼ Sec. 33, T37S, R33E), Highlands Co., Florida.
754. Bermont Fm., south bank of Indian Prairie Canal, at west side of crossing of Florida Highway 721 (SW ¼ Sec. 14, T38S, R32E), 3.8 miles south of Brighton, Highlands Co., Florida.
755. Caloosahatchee Fm., Miami Canal spoil banks, 17.4 miles north of pumping station at Broward county line, Palm Beach Co., Florida.
759. Bermont Fm., spoil banks north side of Caloosahatchee River, two miles west of Ortona Lock (NE ¼ Sec. 29, T42S, R30E), Glades Co., Florida.
767. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks north side of Caloosahatchee River, five miles west of Ortona Lock (NW ¼ Sec. 36, T42S, R29E), Glades Co., Florida.
768. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks north side of Caloosahatchee River, 5½ miles west of Ortona Lock (NW ¼ Sec. 35, T42S, R29E), Glades Co., Florida.
769. Pinecrest Beds, spoil banks east side of Kissimmee River, 1½ to two miles south of U.S. Corps of Engineers Structure 65-D (NE ¼ Sec. 35, T36S, R33E), Okeechobee Co., Florida.
770. Pinecrest Beds and Caloosahatchee Fm. mixed, spoil banks west side of Kissimmee River, 1½ to 3½ miles north of Florida Highway 70 (Secs. 10, 14, 15, and 28, T37S, R33E), Highlands Co., Florida.
777. Anastasia Fm., pits on north side of Florida Highway 710, two miles west of Florida's Turnpike overpass, Palm Beach Co., Florida.
788. Pinecrest Beds and Bermont Fm. mixed, Port Charlotte Development, spoil banks at U-shaped canal on north side of Florida Highway 771, 3.4 miles southwest of U.S. Highway 41 (Sec. 15, T40S, R21E), Charlotte Co., Florida.
790. Ft. Thompson Fm., banks of Florida Cross-State Barge Canal, just south of Inglis, 1.5 miles west of U.S. Highway 19, Citrus Co., Florida.
792. Caloosahatchee Fm., borrow pits just west of Florida Highway 80, about two miles southwest of La Belle (SW ¼ Sec. 7, T43S, R29E), Hendry Co., Florida.
793. Bermont Fm., borrow pits just east of Florida Highway 80, 2½ miles southwest of La Belle (NW ¼ Sec. 18, T43S, R29E), Hendry Co., Florida.
796. Pinecrest Beds, material exposed during construction of "Alligator Alley," 12.8 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.
797. Pinecrest Beds, material exposed during construction of "Alligator Alley," 13.3 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.
803. Bermont Fm., spoil banks south side of Caloosahatchee River, two miles west of Ortona Lock (NE ¼ Sec. 29, T42S, R30E), Glades Co., Florida.
808. Bermont Fm., spoil banks west side of Florida Highway 29, 3.3 miles north of Felda and 16.7 miles south of La Belle, Hendry Co., Florida.
815. Bermont Fm., pits ¾ mile northwest of Ruskin (NW ¼ Sec. 6, T32S, R19E), Hillsborough Co., Florida.
816. Caloosahatchee Fm. and Bermont Fm. mixed, borrow pits, Cecil M. Webb Wildlife Management Area, 1.8 miles east of U.S. Highway 41 and 7.2 miles north of the Lee county line, Charlotte Co., Florida.
870. Waccamaw Fm., pits on east side of North Carolina Highway 130, 2.8 miles north of Old Dock School, Old Dock, Columbus Co., North Carolina.
932. Pinecrest Beds, east side of Kissimmee Canal and ½ mile south of Seaboard Airline Railroad, south of Fort Basinger (SE ¼ Sec. 20, R36S, R33E), Okeechobee Co., Florida.
933. Pinecrest Beds, material exposed during construction of "Alligator Alley," 21.5 miles east of Florida Highway 29, Collier Co., Florida.
936. Anastasia Fm., ditches beside Florida's Turnpike, ten miles north of Ft. Pierce Interchange, St. Lucie Co., Florida.
954. Moín Fm., hill cut immediately behind Standard Fruit Co. box factory, just west of cemetery at Pueblo Nuevo, about 2 km west of Puerto Limon, Costa Rica.

973. Bermont Fm., spoil banks on canal L-38W, 0.8 mile south of Terrytown (which is at Broward-Palm Beach county line), on U.S. Highway 27, Broward Co., Florida.

977. Unnamed post-Pleistocene formation, mud-lump no. 90, mouth of South Pass, Mississippi River delta, Plaquemines Parish, Louisiana.

978. Bermont Fm., spoil banks at pit on south side of waterworks, about 1½ miles northeast of South Bay, Palm Beach Co., Florida.

981. Pinecrest Beds, Port Charlotte Development, spoil banks on south side of U.S. Highway 41, on canal 3.3 miles northwest of Florida Highway 771 (Sec. 3, T40S, R21E), Charlotte Co., Florida.

982. Pinecrest Beds, Port Charlotte Development, spoil banks on northwest side of Florida Highway 771, on canal 3½ miles southwest of junction with U.S. Highway 41 (Sec. 15, T40S, R21E), Charlotte Co., Florida.

985. Pinecrest Beds, Port Charlotte Development, spoil banks about ½ mile northeast of Florida Highway 771, on U-shaped canal 3.3 miles southwest of junction of U.S. Highway 41 (Sec. 10, T40S, R21E), Charlotte Co., Florida.

987. Bermont Fm., spoil banks south side West Palm Beach Canal, at Loxahatchee, on U.S. Highway 98, Palm Beach Co., Florida.

988. Bermont Fm., spoil banks, West Palm Beach Canal at Twenty Mile Bend Recreation Area, about one mile east of junction of U.S. Highway 98 and 441, Palm Beach Co., Florida.

989. Anastasia Fm., Palm Beach county rock pit, Forest Hill Blvd., just east of overpass of Florida's Turnpike, nine miles west of U.S. Highway 1, West Palm Beach, Palm Beach Co., Florida.

990. Anastasia Fm., Powell rock pit, west of Florida Highway 7, between Lake Worth and Lantana, Palm Beach Co., Florida.

991. Caloosahatchee Fm., Cochran rock pit, 2½ miles west of La Belle, on north side of Florida Highway 80, Hendry Co., Florida.

1000. Pinecrest Beds, borrow pit at east end of 17th Street (T36S, R19E), about 8 miles east of U.S. Highway 30 at Sarasota, Sarasota Co., Florida.

1044. Pinecrest Beds, spoil banks, west side of L-28 Interceptor Canal, 3½ miles north of junction with Hendry County Highway 833, north side of Big Cypress Indian Reservation (T47S, R33E), Hendry Co., Florida.

1177. Caloosahatchee Fm., Mule Pen Quarry, north of Florida Highway 846, 9.1 miles east of U.S. Highway 41 at Naples Park (SE ¼ Sec. 24, T48S, R26E), Collier Co., Florida.

The following are Tulane University Recent locality numbers:

R-9. Dredged in 3 to 5 fms. off Longboat Key, Sarasota, Sarasota Co., Florida.

R-17. Southern end of Sunshine Skyway, Tampa Bay, south of St. Petersburg, Manatee Co., Florida.

R-20. Sanibel Island, Lee Co., Florida.

R-44. Isla Mujeres, open ocean side, Quintana Roo, Mexico.

R-46. Puerto Juarez, Quintana Roo, Mexico.

R-98. *Anton Bruun* Cruise 10, dredged in 22 fms., NW of Holandes Cay and ENE of Cape San Blas, Panamá; 9°37'N, 78°50.3'W.

R-105. *Hernan Cortez* Cruise 17, dredged in 18 fms. off Highland Point, 25°33'N, 81°23'W, Monroe Co., Florida.

R-164. Isla Contoy (second island north of Isla Mujeres), Quintana Roo, Mexico.

R-271. Isla Mujeres, northwestern corner of the island, on the sheltered (lagoon) side, Quintana Roo, Mexico.

R-220. Tarpon Bay, in very shallow water, Sanibel Island, Lee Co., Florida.

R-279. Sand bar in front of San Felipe, Yucatán, Mexico.

R-304. Cabo Catoche, about 35 kms east of village of Holbox, Isla Holbox, Quintana Roo, Mexico.

R-306. Playa Sombreron (local name only), rocky beach between two headlands, 22 kms south of Campeche (city), Campeche (state), Mexico.

R-350. Punta Checuzum, north coast of Yucatán, about one-half way between Punta Yalkubul and San Felipe, Yucatán, Mexico.

R-351. Isla El Cerrito, small rocky island with mangroves, about 5 kms west of San Felipe, Yucatán, Mexico.

R-352. Paso del Cerro, rocky point with mangroves, on mainland behind Isla El Cerrito, about 5 kms west of San Felipe, Yucatán, Mexico.

R-353. Yucum Balam, sandy beach with mangroves, about 25 kms north of Campeche (city), Campeche (state), Mexico.

R-354. Rubbly beach at Rancho Niop, 10 kms north of bridge at Champoton, Campeche, Mexico.

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REVIEWS

CONTRIBUTIONS TO THE HISTORY OF GEOLOGY, edited by George W. White, a series of classical works in geology, reprinted in facsimile with introductory biographical and bibliographical commentaries by the editor and other distinguished students of the history of geology, These volumes are handsomely and skillfully reproduced and were carefully selected to make essential but almost unobtainable titles available to students and historians at relatively modest cost. Published by Hafner Publishing Company, Inc., New York.

7. AN ESSAY ABOUT THE ORIGINE AND VIRTUES OF GEMS, by Robert Boyle: facsimile of the 1672 edition, with an introduction by A. F. Hagner and a foreword by George W. White. New York, 1972, xliv +185 pp., $14.95

This edition of Boyle's masterful work on minerals and crystal chemistry was published on the three hundredth anniversary of the original edition, a most fitting way to celebrate this event, which marked the very beginning of chemical mineralogy and founded geochemistry. From his experiments in the laboratory, his observations in the field, and the study of his specimens, Robert Boyle reasoned by analogy and derived his recognition of the relationship of crystal form and structure to the chemical constituents of minerals. He observed the thin plates which formed and stacked one upon another to produce large, thick crystals in the laboratory and compared these with the similar features of natural crystals. He grew crystals from solutions and concluded that transparent gemstones have a similar origin and structure, stating that it is unlikely "that bodies that were never fluid should have the arrangement of their constituent parts, that is requisite to transparency," and noted that the interior "grain" of certain gems and other minerals is visible, and that muscovite and diamond are easily cleaved along the visible plates and along this "grain". In this work he gives a chemical explanation of the supposed mystical or medicinal effects, or "virtues", of gemstones. He explains the petrification of fossils as a replacement process, much as we understand it today. This work by Boyle is clearly one of the true foundation stones of modern geology.

(continued on page 136)

ON THE IDENTITY OF TWO SUPPOSED FACIOLARIID GASTROPODS, *FUSUS MEXICANUS* REEVE, 1848, and *PERISTERNIA NODULOSA* A. ADAMS, 1855

ROBERT C. BULLOCK

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF RHODE ISLAND
KINGSTON, RHODE ISLAND

On the basis of syntypes of *Fusus mexicanus* Reeve, 1848, this neglected species is recognized to be a junior subjective synonym of the western Atlantic muricid *Calotrophon ostrearum* (Conrad, 1846). Syntypes of *Peristernia nodulosa* A. Adams, 1855, another overlooked species, indicate that Adams' species is also not a fasciolariid but a senior synonym of *Attiliosa incompta* (Berry, 1960), the type of the genus *Attiliosa* Emerson, 1968.

Much work is presently being done on the systematics of the New World muricacean gastropods. In spite of this effort, species introduced in the literature continue to be overlooked due to the fact that some of the diverse muricaceans were described as belonging to other gastropod groups. Such is the case with *Fusus mexicanus* Reeve, 1848, and *Peristernia nodulosa* A. Adams, 1855, which have remained unrecognized by recent investigators. Examination of type material of both species has led to the conclusions presented in this paper.

FUSUS MEXICANUS Reeve, 1848

Plate 1, figs. 1-5

Fusus mexicanus REEVE, 1848, Conchologia Iconica, v. 4, *Fusus,* pl. 19, fig. 77.
Urosalpinx mexicanus (Reeve). KOBELT, 1879, Jahrb. Deutsch. Malak. Ges., v. 6, p. 173.
Urosalpinx mexicanus (Reeve). TRYON, 1880, Man. Conch., v. 2, p. 153, pl. 39, fig. 482 (after Reeve).
Urosalpinx mexicanus (Reeve). DALL, 1885, U. S. Geol. Surv., Bull. 24, p. 321.

Type material: Syntypes (3) in the British Museum (Natural History); one figured by Reeve, 1848, pl. 19, fig. 77 (see plate 1, figs. 1, 5).

Type locality: "Mexico" (Yucum Balam, Campeche, TU R-353, here designated).

Remarks: Fusus mexicanus Reeve, 1848, is not mentioned in the works of McLean and Emerson (1970), Keen (1971), Vokes (1971), or Abbott (1974), although: 1) the locality was stated to be Mexico; 2) Kobelt (1879, p. 173) placed *mexicanus* in the *Urosalpinx* group and recorded it from the Gulf of Mexico; 3) Tryon (1880, p. 153) noted: "This may prove to be identical with *U. [Urosalpinx] floridana* Conrad, 1869, and if so, will have priority over that species;" and 4) Dall (1885, p. 321) listed this species as *Urosalpinx mexicanus* in his list of Quaternary and Recent Mollusca from eastern North America.

Reeve's figure rather clearly refers to a species of the genus *Calotrophon.* After a comparison of the beachworn syntypes (plate 1, figs. 1-3) with numerous specimens of this group, one must conclude that *Fusus mexicanus* is conspecific with *"Murex" ostrearum* Conrad, 1846, a species placed by McLean and Emerson (1970) in the genus *Calotrophon* Hertlein and Strong, 1951.

Although the writer was unaware of the existence of this species in Mexico, Emily Vokes (personal communication) advised that it occurs along the western and northern coast of the Yucatán Peninsula. A specimen that is virtually identical to the syntypes is here figured (fig. 4). It comes from a locality to the north of Campeche (TU R-353), which is here designated as the type locality. (See Vokes paper preceding this for additional locality data and complete synonymy.)

PERISTERNIA NODULOSA A. Adams, 1855

Plate 1, figs. 6-8

Peristernia nodulosa A. ADAMS, 1855, Zool. Soc. London, Proc., (1854), p. 313.
Coralliophila nodulosa (Adams). MELVILL, 1891,

Manchester Lit. Phil. Soc., Mem. Proc., (ser. 4) v. 4, pp. 409, 410.

Peristernia nodulosa Adams. HEDLEY, 1908, Linnean Soc. New South Wales, Proc., v. 33, p. 486, pl. 8, fig. 11 (syntype).

Type material: Syntypes (2) in the British Museum (Natural History); Hedley, 1908, pl. 8, fig. 11, figured one of these specimens (see plate 1, figs. 6,7).

Type locality: "Australia."

Remarks: Because so few malacologists have studied members of the Fasciolariidae, certain species, such as *Peristernia nodulosa* A. Adams, have remained members of the family, although their obvious affinities lie elsewhere. Melvill (1891) in his monograph of *Latirus,* correctly noted that *nodulosa* did not belong to that group, and he placed Adams' species in the genus *Coralliophila.* Hedley (1908, p. 486, pl. 8, fig. 11) examined and figured a syntype of this species stating: "This species has not been figured or again noticed in literature. It was originally reported from Australia, but I am not acquainted with an Australian shell like it."

An examination of the syntypes in the British Museum (Natural History) (plate 1, figs. 6,8), leads me to believe that the Adams' species must be considered to be conspecific with a muricacean species described over a century later, *Coralliophila incompta* Berry, 1960. The latter species, the type of the genus *Attiliosa* Emerson, 1968, was placed by Emerson in the Thaidinae, near the genus *Cronia* H. and A. Adams, 1853. Emerson (1968), Vokes (1971), and Keen (1971) made no reference to *Peristernia nodulosa* A. Adams.

Peristernia nodulosa A. Adams, 1855, is here considered to be conspecific with *Attiliosa incompta* (Berry, 1960) and, being an earlier name, the correct name for this eastern Pacific species should be *Attiliosa nodulosa* (A. Adams, 1855).

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PLATE 1

Figures

1-5. *Calotrophon ostrearum* (Conrad) (X 2)

1-3. British Museum (Nat. Hist.). Syntypes of *Fusus mexicanus* Reeve. Locality: Mexico. Recent.

4. USNM 711119; height 22.0 mm, diameter 11.5 mm. Locality: TU R-353, Yucum Balam, Campeche, Mexico. Recent.

5. Reeve, 1848, Conchologia Iconica, v. 4, *Fusus,* pl. 19, fig. 77.

6-8. *Attiliosa nodulosa* (A. Adams) (X 2)

6, 8. British Museum (Nat. Hist.). Syntypes of *Peristernia nodulosa* A. Adams. Locality: "Australia." Recent.

7. Hedley, 1908, Proc. Linn. Soc. New South Wales, pl. 8, fig. 11.

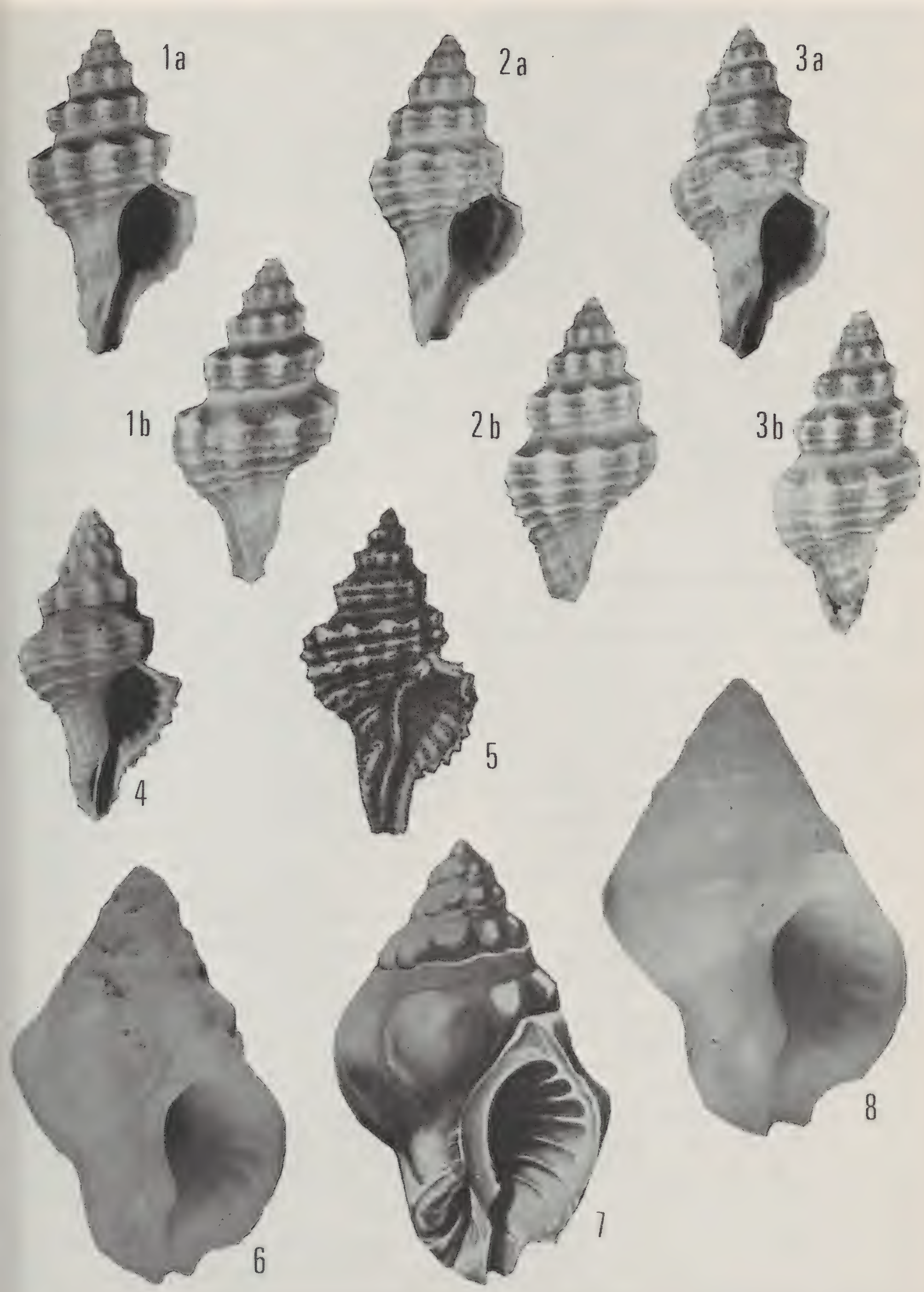

PLATE 1

BERRY, S.S., 1960, Notices of new eastern Pacific Mollusca — IV: Leaflets in Malacol., v. 1, no. 19, p. 115-122.

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September 15, 1976

(continued from page 132)

8. GEOLOGY OF EASTERN NORTH AMERICA, by Johann David Schopf; an annotated translation of *Beytrage zur Mineralogischen Kenntniss des Ostlichen Thiels von Nord-Amerika und seiner Geburge, 1787,* by Edmund M. Spieker (translator) with a foreword by George W. White; and, a facsimile reprint of the original German text. New York, 1972, x + 171 pp.; xii + 195 pp. (in facsimile), folded map.

Schopf's sojourn in the United States and the published report of his geologic investigations date from the earliest days of geology as an established science. His book is the first serious and comprehensive attempt to describe the geology of North America. However, it was almost totally unknown in America until 1894 when the first commentary on his work was published (Williams, *Bull. Geol. Soc. America,* v. 5, pp. 591-593). This fact, together with the rarity of the volume, have combined to prevent adequate appreciation of its value as a pioneering work on the geology of this country. Schopf's work is based on field observations and is more comprehensive than that by Volney (1803) and Maclure (1809) to whom he seems to have been unknown. If it had come to notice earlier, then Johann Schopf rather than William Maclure might be known as the "Father of American Geology". In the present edition, the full text is available for the first time in English and re-evaluation of Schopf's contributions (from this more easily readable form) is made possible.

BENCHMARK PAPERS IN GEOLOGY, edited by Rhodes W. Fairbridge, selected anthologies of papers or journal articles from the geological literature on various phases of geological research, reprinted with an introduction by the volume editor and a "highlight commentary" on each "benchmark paper". Published by Dowden, Hutchinson & Ross, Inc., Stroudsburg, Pennsylvania; distributed by Halsted Press, a division of John Wiley & Sons., Inc., New York.

22. PLANATION SURFACES: PENEPLAINS, PEDIPLAINS, AND ETCHPLAINS, edited by George F. Adams. 1975, thirty-three papers, xv + 476 pp., $28.00

23. GEOCHEMISTRY OF BORON, edited by C. T. Walker. 1976, thrity-four papers, xvii + 414 pp., $35.00

25. ENVIRONMENTAL GEOLOGY, edited by Frederick Betz, Jr. 1975, thirty-two papers, xv + 391 pp., $27.00 —H.C.S.

THE CRYSTAL RIVER FORMATION (EOCENE) AT MARTIN, MARION COUNTY, FLORIDA

DAVID NICOL
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

GRAIG D. SHAAK
FLORIDA STATE MUSEUM
GAINESVILLE, FLORIDA

JOHN W. HOGANSON
UNION OIL COMPANY OF CALIFORNIA
HOUSTON, TEXAS

ABSTRACT

Although several paleontologists have mistakenly said that Martin Station is located in Hernando County, Dall clearly stated that it was a railway station at Martin, Marion County, Florida, which is about ten miles north of Ocala. The importance of this place is that it is the type locality for *Turritella martinensis* Dall, which MacNeil and others have used as a zone fossil for lower Oligocene strata in Mississippi, Alabama, and Florida.

The authors suggest that the strata at Martin are Eocene in age. There appears to be no Oligocene beds in the immediate vicinity of Martin. We believe that the Eocene-Oligocene boundary in Florida should be placed between Puri's *Asterocyclina-Spirulaea vernoni* zone and his *Lepidocyclina chaperi* zone.

INTRODUCTION AND DESCRIPTION OF THE LOCALITY

Some of the earliest fossil collecting done by the United States Geological Survey in Florida was in the vicinity of Gainesville and Ocala, in Alachua and Marion Counties respectively. These fossils were later described by Dall (1890-1903) in *Contributions to the Tertiary fauna of Florida.* One of the important localities whence Eocene invertebrate fossils were collected was a place referred to by Dall as "Martin Station." Under the heading, *The Ocala Limestone, or Nummulitic Rock of Heilprin,* Dall (1903, p. 1556) clearly stated where this place was located: "The fauna of the limestone appears to be the same as that of a much silicified country rock quarried at Martin, a railway station about ten miles north of Ocala in Marion County." The location of Martin Station is shown in Figure 1. Despite this statement, Schuchert *et al.* (1905), refer to the Martin Station locality as being in Hernando County, Florida, for *Turritella indenta* var. *martinensis* Dall (p. 677) and for *Cerithium ocalanum* Dall (p. 140). Apparently this error arose from the fact that labels with the specimens from Martin Station in the National Museum of Natural History read Hernando County rather than Marion County. Druid Wilson (personal communication) said that it seems improbable that any of the material listed by Dall came from Hernando County. Both Bowles (1939, p. 283) and MacNeil (1944, p. 1317, and 1946, p. 48) accepted the type locality of *Turritella indenta* var. *martinensis* as being in Hernando County because they were misled by the erroneous locality data on the labels. Other paleontologists, *e.g.* Palmer and Brann (1966, p. 933 and p. 880), have also cited the Martin Station locality as being in Hernando County for *Turritella indenta* var. *martinensis* and *Cerithium ocalanum* respectively, but these authors may have taken this error from the literature. There are undoubtedly other paleontologists who have perpetuated this error in print, but we have not attempted to ferret out additional references.

EDITORIAL COMMITTEE FOR THIS PAPER:
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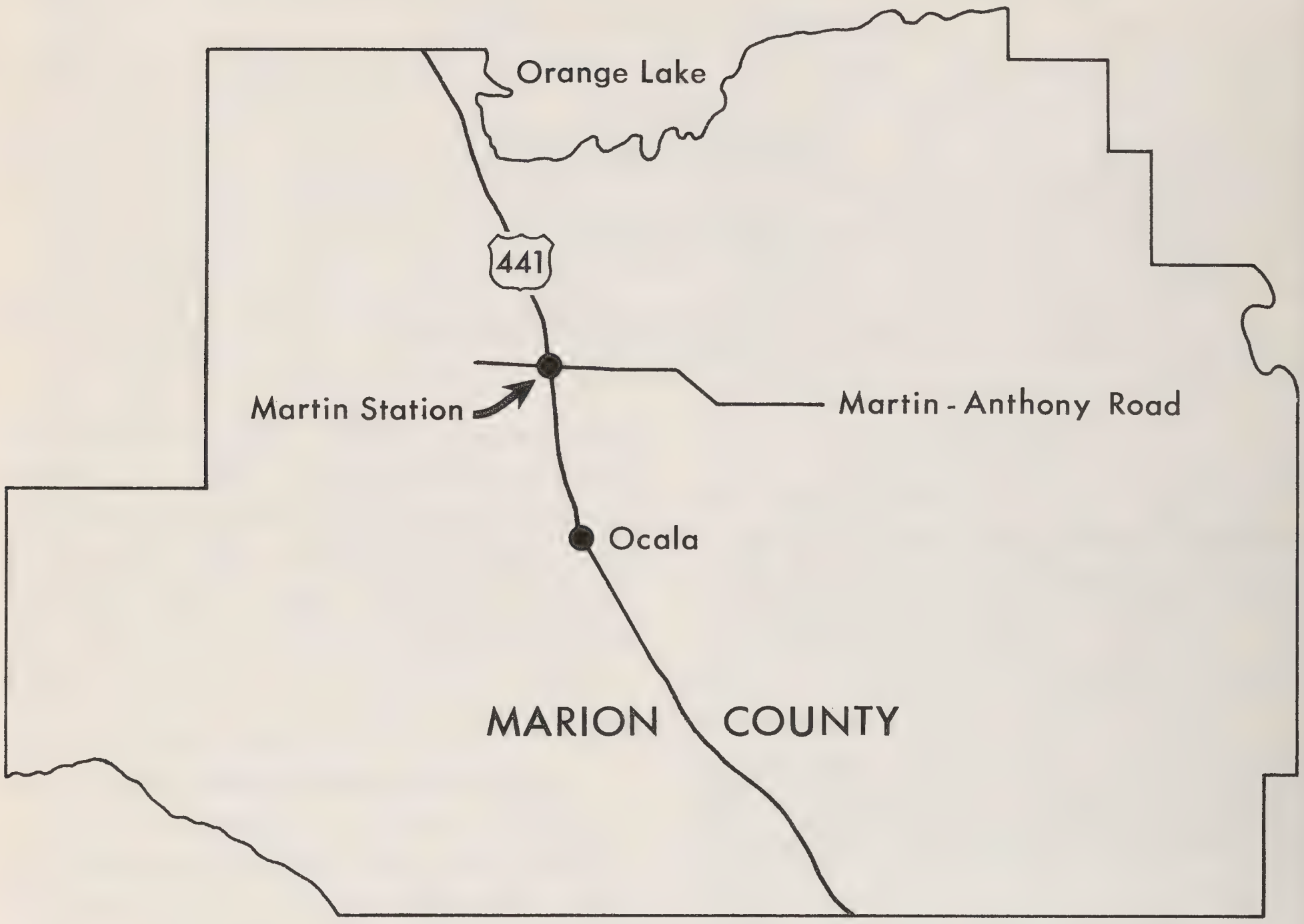

Figure 1. Map of Marion County, Florida, showing the location of Martin Station.

Dall's *Turritella indenta* var. *martinensis* is now called *Turritella martinensis* in the more recent paleontologic and stratigraphic literature except that of Allison and Adegoke (1969, p. 1263), who believe that the species *martinensis* should more properly be allocated to the genus *Torcula* Gray, 1847. However, for the purpose of this paper, we will refer to this species as *Turritella martinensis* because stratigraphers have used it as a zone fossil and have consistently so called it. *Cerithium ocalanum* Dall is classified as *Rhinoclavis (Ochetoclava) ocalana* by Palmer and Brann (1966, p. 880).

The fossils described by Dall from Martin Station are in a brown to greyish-brown chert, and most of them are well preserved and easily identifiable. The chert was quarried, crushed, and used principally for railroad ballast. There are still some chert boulders in an elongate depression east of the railroad tracks near where the railroad station at Martin was formerly located. One of the commonest fossils found in these boulders is a small species of turritellid, which agrees in morphological characteristics with Dall's brief description of *Turritella martinensis* (1892, p. 308-309); a specimen is shown in Figure 2. In some of the boulders *Amusium ocalanum* Dall is abundant (Figure 3). A small species of *Glycymeris* and a small solitary coral were also seen.

The elevation at Martin is about 80 feet, but hills nearby are more than 160 feet above sea level. Above the Crystal River Formation of the Ocala Group is, in places, a richly fossiliferous marine limestone that ranges in thickness from about two to 15 feet. This bed also contains several species of terrestrial gastropods. Cooke (1945, p. 114, 129-130) referred these patches or outliers of limestone to the Tampa Limestone, which is the St. Marks Formation of Puri and Vernon (1964, p. 117). However, Puri (1957, p. 72) questionably called this lime-

Figure 2. A chert boulder from Martin Station containing a specimen of *Turritella martinensis*.

stone the Hawthorne Formation, and Wilson *in* Espenshade and Spencer (1963, p. 18-19, 25, and Table 10) also placed it in the Hawthorne. In any event, all of the paleontologists who have studied the fauna of this limestone have considered it to be early Miocene in age.

On some of the higher hills in this region, as much as 40 feet of unquestionable Hawthorne Formation crops out. Brooks *et al.* (1967, p. 25-27) described a section from 2.6 miles east of Martin where the Martin-Anthony road crosses U.S. Highway 301.

The chert in the Crystal River Formation has replaced the original limestone that was dissolved by ground water. The source of the silica must have been mainly the clay minerals in the Hawthorne Formation. The Hawthorne Formation is found on the hills in this area as outliers, but this formation has been eroded away at places like Martin, where the elevation is only 80 feet above sea level. The chert is not an indicator of the age of the beds because chert has replaced limestone in several of the upper zones of the Crystal River Formation in Marion and Alachua Counties.

THE AGE OF THE BEDS AT MARTIN STATION

In the list of species from Martin Station, Dall (1903, p. 1557-1558) claimed that 14 of them are also found in the Ocala Limestone, eight also from the Vicksburg, and six also from the Silex Beds (Tampa Limestone). Druid Wilson (personal communication) told the senior author that some of the fossils collected at Martin Station indicate

Figure 3. A chert boulder from Martin Station showing part of a specimen of *Amusium ocalanum.*

Vicksburgian affinities. It is worth noting, in this regard, a statement made by Cheetham (1963, p. 10) concerning his bryozoan zones in the Jacksonian. "The upper zone of the Jacksonian, the *Floridina antiqua* zone, includes not only the greatest diversity of cheilostome bryozoans (85 species) but also the largest percentage of species peculiar to a zone of the Jacksonian (39 per cent). The zone is characterized by commingling of species restricted to the Jacksonian and species of Oligocene aspect. The bulk of the assemblage, 58 species, has Jacksonian affiliation; only six species whose first appearance occur in this zone continue into overlying deposits. The *Floridina antiqua* zone occupies approximately the same stratigraphic interval as the *Nummulites vanderstoki-Hemicythere* and *Asterocyclina-Spirolaea [sic] veroni* zones of Puri and the *Textularia hockleyensis* zone of Stuckey." For a comparison of Cheetham's (1963) and Puri's (1957) zonations of the Ocala Group, see Figure 4.

The abundance of *Amusium ocalanum* in the fauna from Martin Station is an excellent indicator that the highest zone in the Ocala Group from which these fossils probably come is Puri's *Nummulites vanderstoki-Hemicythere* zone because *Amusium ocalanum* is either exceedingly rare or absent above this zone in peninsular Florida (McCullough, 1969, p. 10). Furthermore, none of the characteristic zone fossils of the next overlying zone, the *Asterocyclina-Spirulaea vernoni* zone, were found in the Martin Station fauna. Some of the diagnostic fossils for this latter zone are *Spirulaea*

OCALA GROUP FAUNAL ZONES

				PURI	CHEETHAM
UPPER EOCENE	JACKSON STAGE	OCALA GROUP	CRYSTAL RIVER	Lepidocyclina chaperi	Spondylus dumosus
				Asterocyclina - Spirulaea vernoni	Floridina antiqua
				Nummulites vanderstoki - Hemicythere	
				Lepidocyclina - Pseudophragmina	Tubucellaria nodifera
				Spiroloculina newberryensis	
			WILLISTON	Operculinoides moodybranchensis	Periarchus lyelli
				Operculinoides jac onensis	
			INGLIS	Periarchus lyelli floridanus - Plectofrondicularia? inglisian	

Figure 4. A comparison of Puri's and Cheetham's zonation of the Ocala Group. The writers consider Puri's *Lepidocyclina chaperi* zone and Cheetham's *Spondylus dumosus* zone to be Oligocene.

vernoni Richards, *Chlamys (Lyropecten) incertae* Tucker-Rowland, *Chione* sp., and *Wythella eldridgei* (Twitchell). *Asterocyclina* is rare in peninsular Florida and is not a useful marker for this zone.

Excluding Puri's highest zone of the Ocala Group, the *Lepidocyclina chaperi* zone, which appears to be absent in at least the northern half of the Ocala Uplift, the two most distinct megafossil changes within the Ocala Group are between the *Periarchus lyelli floridanus-Plectofrondicularia? inglisiana* zone and the *Operculinoides jacksonensis* zone, which separate the Inglis and Williston Formations; and between the *Nummulites vanderstoki-Hemicythere* zone and the *Asterocyclina-Spirulaea vernoni* zone. The *Asterocyclina-Spirulaea vernoni* zone has such a distinctive assemblage of megafossils that its presence would be difficult to overlook and we did not see this zone in any outcrops nearest to Martin.

Puri (1957, pl. 3) indicated in an isometric projection of the Ocala Group that the highest zone found in the vicinity of Martin is the *Lepidocyclina-Pseudophragmina* zone, which is immediately below the *Nummulites vanderstoki-Hemicythere* zone, as shown in Figure 4.

We examined the limestone at two quarries; one 0.8 of a mile south of Martin, the other 2.0 miles north of Martin. At these places the highest zone seen was either the lower part of the *Nummulites vanderstoki-Hemicythere* zone or the upper part of the *Lepidocyclina-Pseudophragmina* zone. There appears to be no strata of Oligocene age in the immediate vicinity of Martin. We have come to the conclusion that there is probably a structural high in the Ocala Uplift in the area of Martin Station, which extends eastward to Anthony, Sparr, and Citra.

A problem has arisen because MacNeil has used *Turritella martinensis* (1944, p. 1317, footnote, and 1946, p. 48-49, 55) as a zone fossil for lower Oligocene strata in Mississippi, Alabama, and Florida. In 1944, MacNeil claimed that this species is abundant in the upper part of the Forest Hill Sand of Mississippi. In 1946 (p. 55) he correlated his *Turritella martinensis* zone with the Marianna Limestone of Florida and Mississippi and the

Mint Spring Marl Member in Mississippi. These stratigraphic units were placed in the lower Vicksburg Group in his restricted use of the Vicksburg (1944) and were not considered to be the lowest Oligocene by him because he placed the Forest Hill Sand and the Red Bluff Clay of Mississippi at the base of the Oligocene, considering these lithologic units to be equivalent to the *Lepidocyclina fragilis* zone=*Lepidocyclina chaperi* zone of Florida.

MacNeil (1946, p. 48) stated that *Turritella martinensis* occurs abundantly in a large quarry about five miles southeast of Crystal River in Citrus County (very likely the type locality of the Crystal River Formation) and at water level on the Suwannee River at Ellaville, which is the type locality of the Suwannee Limestone. At the latter locality MacNeil noted that the bed at water level had been variously referred to the Byram and the Ocala Formations. Hunter (1972, p. 21, *in* Banks, Reves, and Hunter) stated that the lower beds at Ellaville are Bumpnose Limestone, which she placed in the Red Bluff Stage. Randazzo (1972, p. 333) stated that the lower part of the section at Ellaville is suspected as being Eocene Crystal River Formation. Downstream from Ellaville about ten miles, in a large quarry west of Dowling Park in Lafayette County, Hoganson (1972, p. 32) found as much as ten feet of the *Asterocyclina-Spirulaea vernoni* zone overlain by the Suwannee Limestone. It is most likely that the bed at water level at Ellaville is the *Asterocyclina-Spirulaea vernoni* zone of the Crystal River Formation, but this has not as yet been proved. MacNeil said that this bed has a Mint Spring molluscan fauna. MacNeil (1946, p. 49) redefined the Suwannee Limestone so as to include the *Turritella martinensis* zone as a lower member of this formation in northern and peninsular Florida.

Hunter (1972, p. 21, *in* Banks, Reves, and Hunter) considered *Turritella martinensis* a marker for the Bumpnose Limestone, which she and many other stratigraphers believe to be the oldest Oligocene rocks in Florida. Allison and Adegoke (1969, p. 1263) have quoted a statement from Druid Wilson that, "apparently a thin bed of silicified Oligocene limestone occurs rather widely above the 'Ocala' Eocene. At some places north of Ocala, silicified Oligocene and Eocene fossils are mixed together and lie upon the eroded top of the Eocene. *Turritella martinensis* apparently came from the Oligocene." Mainly on the basis of these assertions and some fossil identifications by Wilson from Martin Station or nearby, Allison and Adegoke came to the conclusion that *Torcula martinensis martinensis=(Turritella martinensis)* is an Oligocene species and possibly restricted to early Oligocene. However, Adegoke in this same publication, described *Torcula martinensis henkeri* from the Department of Bolivar, Colombia, in strata he considered middle to late Eocene in age.

Although *Turritella martinensis* may be a useful index fossil for lower Oligocene strata in Mississippi, Alabama, and Florida, it has led to the belief that some beds in Florida are Oligocene in age when they are actually late Eocene in age. At Martin Station, the type locality of *Turritella martinensis,* this species ranges downward into at least the *Nummulites vanderstoki-Hemicythere* zone and possibly into the *Lepidocyclina-Pseudophragmina* zone, both of which are considered to be Eocene in age. In silicified boulders in Alachua County, *Turritella martinensis* has been found with *Spirulaea vernoni,* a zone fossil for the *Asterocyclina-Spirulaea vernoni* zone (Williams, 1974, p. 65).

THE EOCENE-OLIGOCENE BOUNDARY IN FLORIDA

There is not complete agreement as to where in the stratigraphic section in Florida the Eocene-Oligocene boundary should be placed. Moore (1955, p. 19) placed his Bumpnose Limestone at the top of the Eocene. This is the equivalent of Puri's *Lepidocyclina chaperi* zone, and Puri (1957, p. 5, 34) and Puri and Vernon (1964, p. 43, 58) followed Moore in this regard. MacNeil (1944, fig. 1, p. 1315; 1946, p. 55; 1966, p. 3252) and Cheetham (1963, p. 7) placed the Bumpnose Limestone at the base of the Oligocene, as did Huddlestun and Toulmin (1965, p. 159), Toulmin (1969, p. 475), and Hunter (1972, p. 14, *in* Banks, Reves, and Hunter). Cheetham (1963, p. 10) stated his reason for placing the *Lepidocyclina chaperi*

zone at the base of the Oligocene: "Cheilostome bryozoans in the uppermost part of the Ocala Group, in the 'Shubuta' Clay, and in the Red Bluff Marl are more closely akin to those of the Vicksburgian (Oligocene) than to those of the Jacksonian. Therefore, these deposits have been referred to an Oligocene biostratigraphic unit, the *Spondylus dumosus* zone (Cheetham, 1957). Only 51 per cent of the 39 species of cheilostomes in this zone are known to occur in underlying deposits, whereas 87 per cent have been recorded in overlying beds (App. 2). The contact between the *Floridina antiqua* and *Spondylus dumosus* zones is apparently the major faunal discontinuity in Eocene-Oligocene deposits in the eastern Gulf Coast region. The *Spondylus dumosus* zone occupies the same interval as the *Lepidocyclina chaperi* zone defined by Puri. However, Puri has not recognized this zone in the Florida peninsula."

Beginning with the *Nummulites vanderstoki-Hemicythere* zone, some of the prominent Tethyan elements become rare or disappear, as for example *Exputens ocalensis* (MacNeil) and *Gisortia harrisi* Palmer. At the top of this zone, *Amusium ocalanum* disappears from peninsular Florida. *Turritella martinensis* either appears in this zone or possibly in an even lower zone, the *Lepidocyclina-Pseudophragmina* zone. In the *Asterocyclina-Spirulaea vernoni* zone, the Oligocene elements of the fauna become much more prominent and numerous. *Chlamys (Lyropecten) incertae* Tucker-Rowland appears, and this large-ribbed pectinid species resembles *Chlamys (Aequipecten?) flintensis* Mansfield (1937, pl. 14, figs. 1, 3), but it is considerably smaller than this latter species. *Chlamys (Lyropecten) incertae* resembles some other Oligocene species of pectinids but not any other pectinid species found in older Ocala strata. A probably unnamed species of *Chione,* which Palmer (1927) and Davies (1971) do not record in beds as old as Eocene, becomes abundant in the *Asterocyclina-Spirulaea vernoni* zone, and also a species of *Glycymeris* with split ribs that closely resembles *Glycymeris lamyi tampae* Mansfield (1937, pl. 10, figs. 4, 6-7). The presence of the echinoid genus *Phyllacanthus,* which Davies (1971) does not report from beds older than Oligocene, is another indicator that the *Asterocyclina-Spirulaea vernoni* zone may be Oligocene rather than Eocene. Furthermore, Puri (1957, p. 119), reporting the foraminiferid *Bitulogenerina vicksburgensis* Howe as commonly occurring in the *Asterocyclina-Spirulaea vernoni* zone, stated that previous occurrences of this species have been from the Oligocene, and that this species is considered to be a good marker for the Vicksburg.

Should the Eocene-Oligocene boundary be drawn below the *Asterocyclina-Spirulaea vernoni* zone in Florida? The presence of a species of *Chione,* the split-ribbed species of *Glycymeris, Phyllacanthus,* and some other groups that resemble Oligocene or even early Miocene relatives, might favor this action. However, when various groups of animals are traced carefully back in time, we frequently find that their first occurrence is in strata older than previously supposed.

On the other hand, the presence of the following genera and subgenera: *Asterocyclina, Hantkenina, Cribrogloborotalia, Pseudophragmina (Proporocyclina),* among the foraminiferids; the annelid worm *Spirulaea;* the echinoid genera *Wythella, Weisbordella, Eurhodia, Phymosoma;* that are either restricted to, or have not as yet been found in strata younger than the Eocene, point to an Eocene age for the *Asterocyclina-Spirulaea vernoni* zone. The generic and subgeneric ranges were taken from Davies (1971) Durham (1966) and Loeblich and Tappan (1964).

We believe that the evidence from the local fossil record indicates that the Eocene-Oligocene boundary in Florida should be drawn between the *Asterocyclina-Spirulaea vernoni* zone and the *Lepidocyclina chaperi* zone. This would place the Eocene-Oligocene boundary at the top of the Crystal River Formation, with the Bumpnose Limestone at the base of the Oligocene section.

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September 15, 1976

THE GENUS *VOORTHUYSENIELLA* (PROBLEMATICA) AT LITTLE STAVE CREEK, ALABAMA

DREW HAMAN and BARRY KOHL

CHEVRON OIL COMPANY, NEW ORLEANS
GEOLOGY DEPT., TULANE UNIVERSITY

I. ABSTRACT

The occurrence of the problematic genus *Voorthuyseniella* Szczechura, 1969, at Little Stave Creek, Alabama, is discussed. Observations are made on the stratigraphic range, paleoenvironmental associations, and possible affinities of this taxon. A new species, *Voorthuyseniella stavensis,* is established.

II. INTRODUCTION

Voorthuysen (1949) first recorded *"Lagena" - x* in the Netherlands Pliocene, and since that date many authors have recorded this taxon from different parts of the world at various stratigraphic horizons, from the upper Eocene to Recent. Szczechura (1969) formalized this taxon by introducing the name *Voorthuyseniella* with *V. lageniformae* n. sp. *(V. lageniformis* of Keij, 1970), as the type species. All the known data on this genus was summarized and evaluated in a detailed article by Keij (1970).

Keij *(ibid.)* was the first to record *Voorthuyseniella* from the Gulf Coast province, recording three species. *Voorthuyseniella occidentalis* Keij, from the Gulf of Mexico, occurred at N28°33', W94°12'15" (36 meters depth); N28°37'10", W94°13'15" (33 meters depth); N28°42'15", W94°01'30" (28 meters depth); and N28°13', W94° (29 meters depth). A type locality was selected for this species at N28°43'15", W94°15' (27 meters depth with a silty clay bottom). Occurrence was common to abundant (180+ specimens) and was regarded as Recent in age. A single test of *Voorthuyseniella* cf. *irregularis* Keij, was noted in the basal Red Bluff Formation at Shubuta Hill, Wayne County, Mississippi. Four specimens of *Voorthuyseniella ablabamensis* Keij, n. sp., were reported from the Mint Spring Marl Member of the Marianna Formation at Little Stave Creek. A single specimen of this species was noted in the Red Bluff Formation at the Lone Star Cement Company Quarry at St. Stephens Bluff on the Tombigbee River.

III. DISCUSSION

The description of *V. alabamensis* from Little Stave Creek by Keij prompted us to further examine selected samples from this locality in order to determine, if possible, the stratigraphic range, paleoenvironmental associations, and possible affinities of this problematic taxon. Prescise locality data was not given by Keij for *V. alabamensis,* other than simply from the Mint Spring Marl member of the Marianna Limestone. We examined samples from the following Bandy (1949) localities: 67 to 61 (inclusive), 56, 54, 45, 42, 35, 33, 21, 9, 8. These localities represent the stratigraphic units of the Little Stave Creek section as indicated below:

Stratigraphic Unit	Bandy localities
Marianna Formation	
Marianna Limestone Member	67, 66
Mint Spring Marl Member	65, 64
Red Bluff Formation	63-61
Yazoo Formation	
Cocoa Sand Member	56
North Twistwood Creek Clay Member	54
Moodys Branch Formation	45, 42
Gosport Formation	35
Lisbon Formation	33, 21
Tallahatta Formation	9, 8

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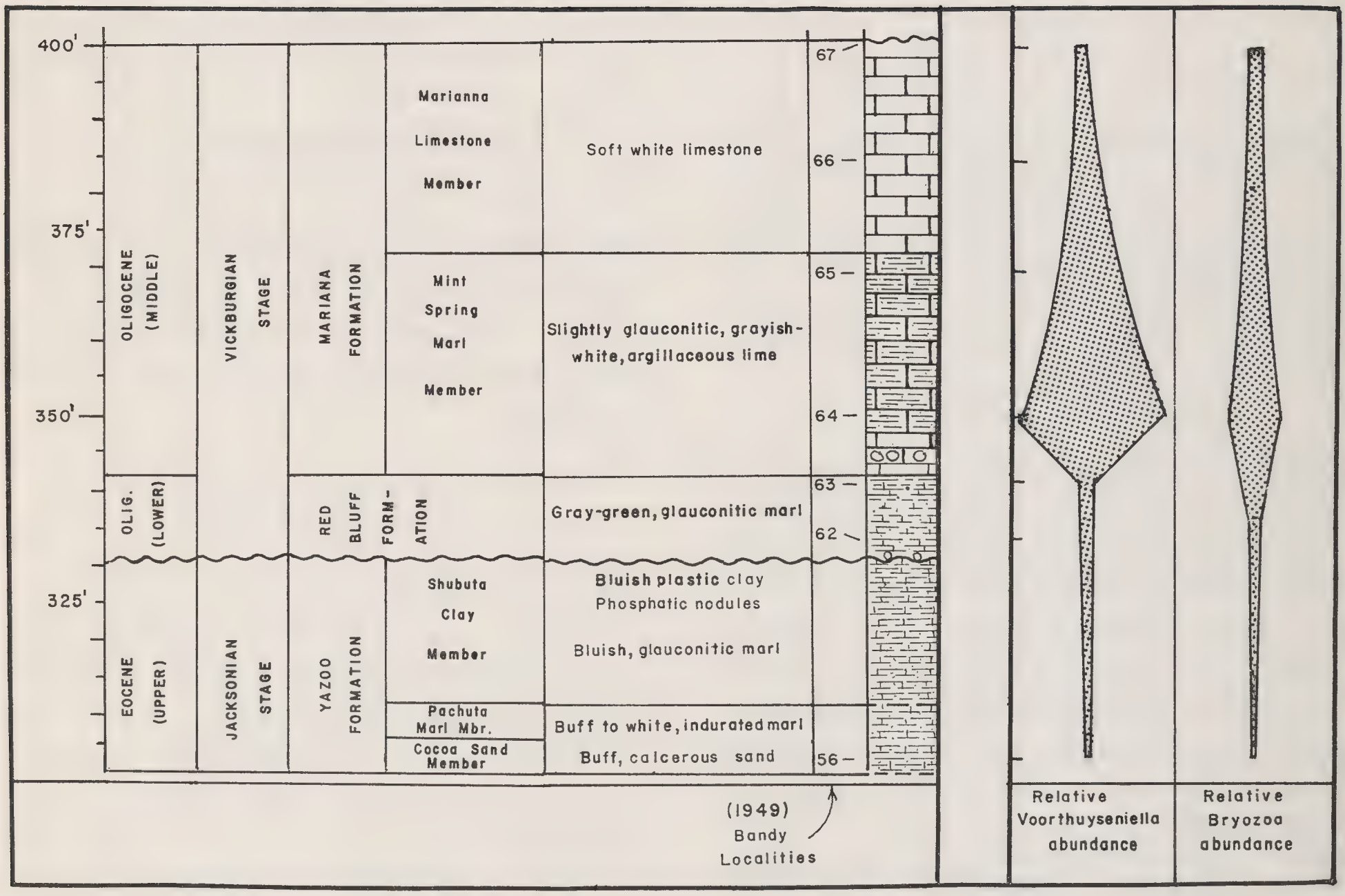

Text-figure 1. Little Stave Creek stratigraphic section with samples containing *Voorthuyseniella* indicated. Relative occurrence of *Voorthuyseniella* and bryozoa plotted for each sample. Modified after Bandy, 1949.

Of these samples only samples 67-62 and 56 contained *Voorthuyseniella* specimens. Over 175 specimens were retrieved in varying abundances from these seven samples (a total volume of approximately 50 ml of dry residue). The stratigraphic range of *Voorthuyseniella* in Little Stave Creek is determined to be from the Cocoa Sand

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PLATE 1

VOORTHUYSENIELLA ALABAMENSIS Keij
(Bar = 100 microns)

Figs. 1, 2 Locality #67. (1) Side view (2) portal view; same specimen.
Figs. 3-5 Locality #66. (3) Side view (4) portal view
(5) View to 'A' lateral aperture; same specimen.
Fig. 6 Locality #66. View of tubus and tubus pore.
Fig. 7 Locality #66. View of tubus and tubus pore.
Fig. 8 Locality #64. View of tubus and tubus pore.
Figs. 9, 10 Locality #66. (9) Side view (10) Portal view; same specimen.

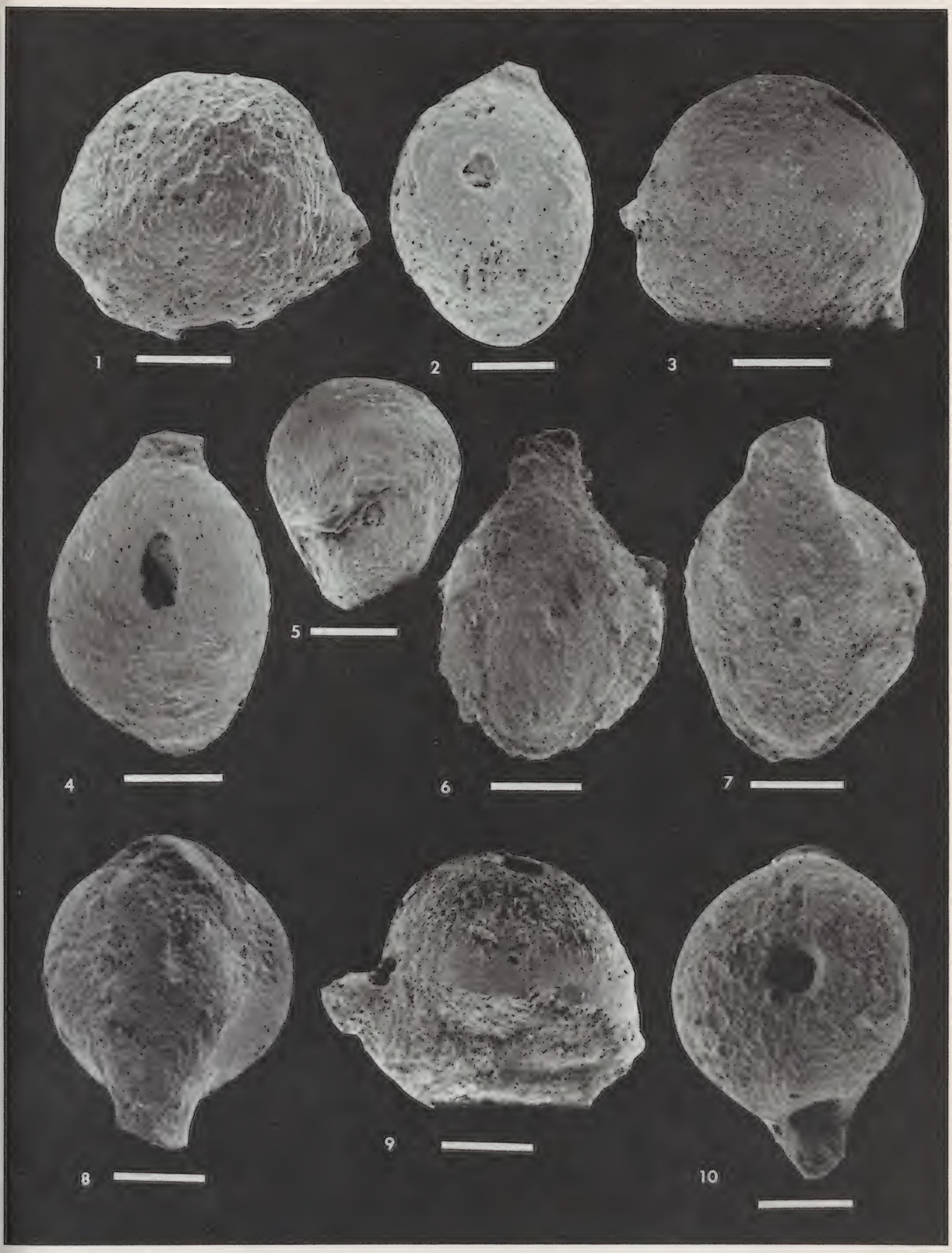
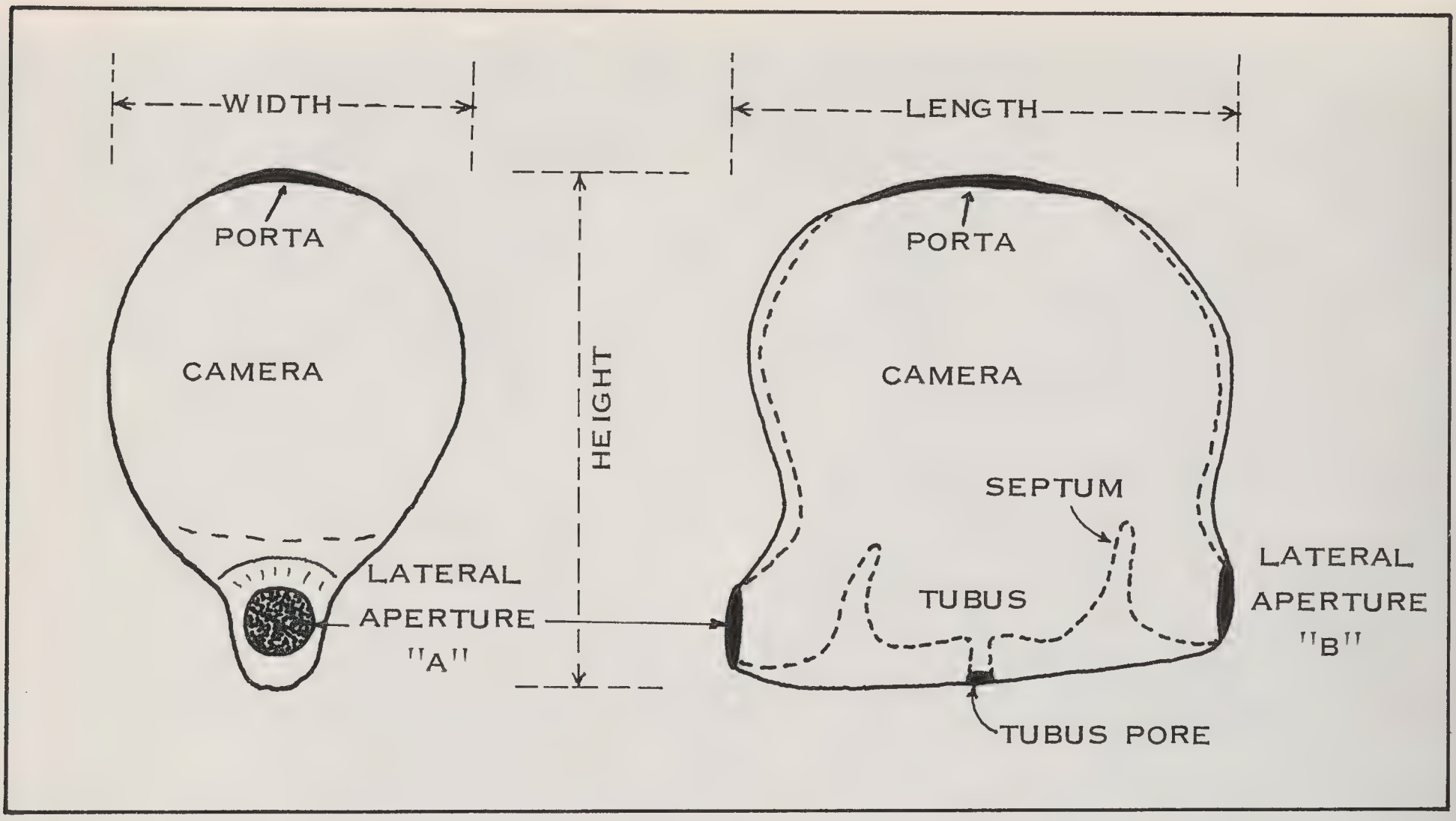


PLATE 1



Text-figure 2. Orientation and taxonomic morphology of *Voorthuyseniella* test (after Szczechura, 1969, and Keij, 1970).

Member of the Yazoo Formation (U. Eocene) to the Marianna Limestone Member of the Marianna Formation (M. Oligocene).

A number of stratigraphers including MacNeil (1944), Cheetham (1957), Murray (1961), Deboo (1965), Howe (1970), and Howe and Howe (1973), have commented on the Eocene-Oligocene boundary (Jackson-Vicksburg) in this area. Stratigraphic terminology utilized in this report is based partially on the works of these authors and also on Field Trip Guides published by the Gulf Coast Association of Geological Societies in particular those of 1962 and 1975. Blow (1969) indicates that in Little Stave Creek an unconformity exists at the base of the Red Bluff Formation, resulting in the absence of Zone P17 *(Globigerina gortanii gortanii–Globorotalia (Turborotalia) centralis* Partial range zone). Although this unconformity was not recognized by Bandy, he did note some features that might result from an unconformity. For example, he commented on the Red Bluff "Clay" as containing a fauna which "is a transitional assemblage with numerous mixed Oligocene and Eocene forms" (1949, p. 44). Further, in his summary (p. 47) he noted the presence of the "good index markers" for the Eocene, *Planulina cocoaensis, Palmula henbesti,* and *Hantkenina alabamensis,* in Oligocene strata. He postulated an extension of the species' vertical ranges for these anomalous occurrences, rather than regarding them as reworked elements at an unconformity. We believe the observations of

PLATE 2

VOORTHUYSENIELLA ALABAMENSIS Keij
(Bar = 100 microns)

Figs. 1, 2 Locality #64. (1) Portal view (2) Side view; same specimen.
Fig. 3 Locality #64. View of tubus and tubus pore.
Figs. 4, 5 Locality #64. (4) Side view (5) Portal view; same specimen.
Figs. 6, 7 Locality #64. (6) Side view (7) View to 'B' lateral aperture; same specimen.
Figs. 8, 9 St. Stephens Bluff. (8) Oblique side view (9) Portal view; same specimen.

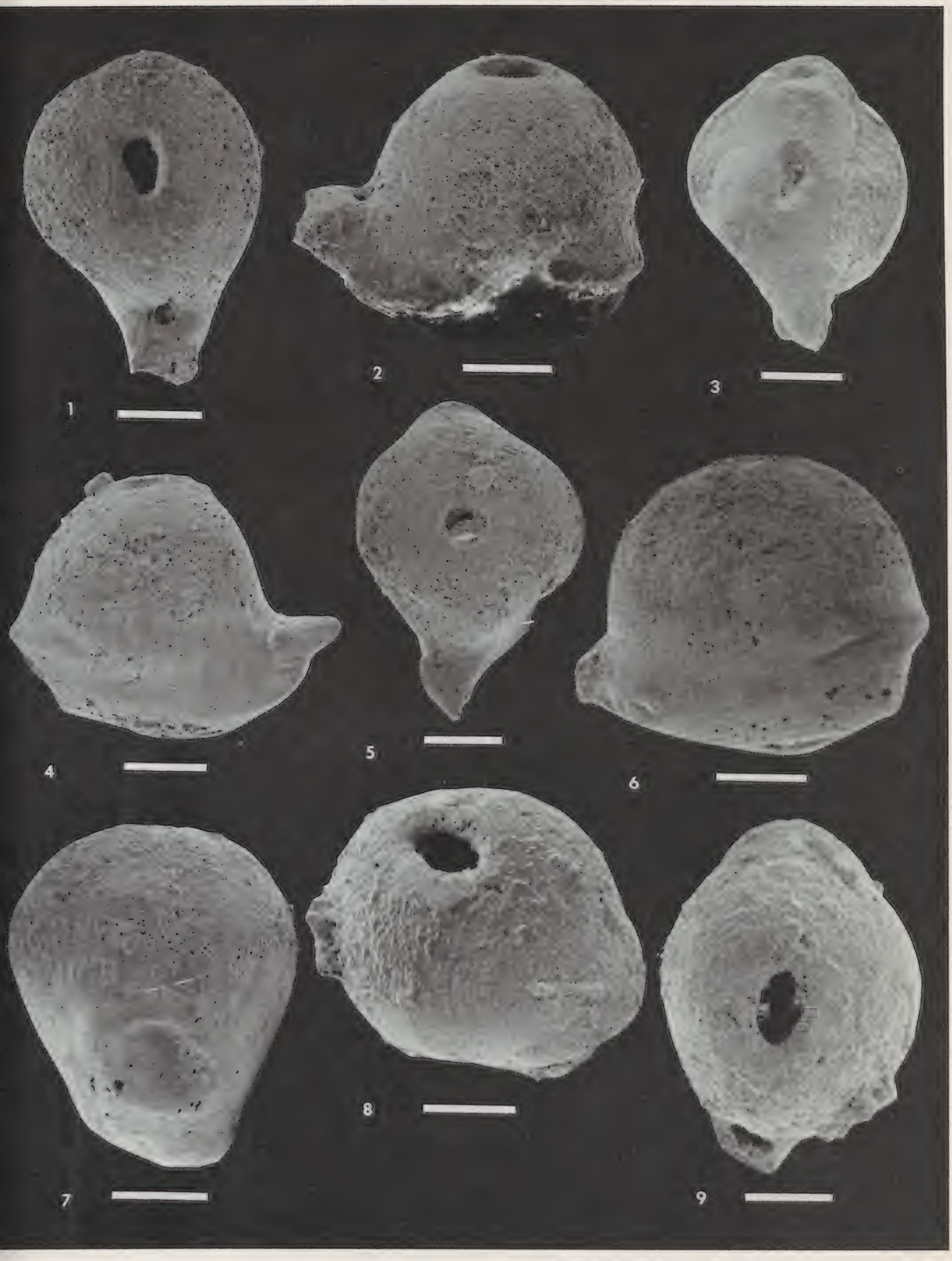
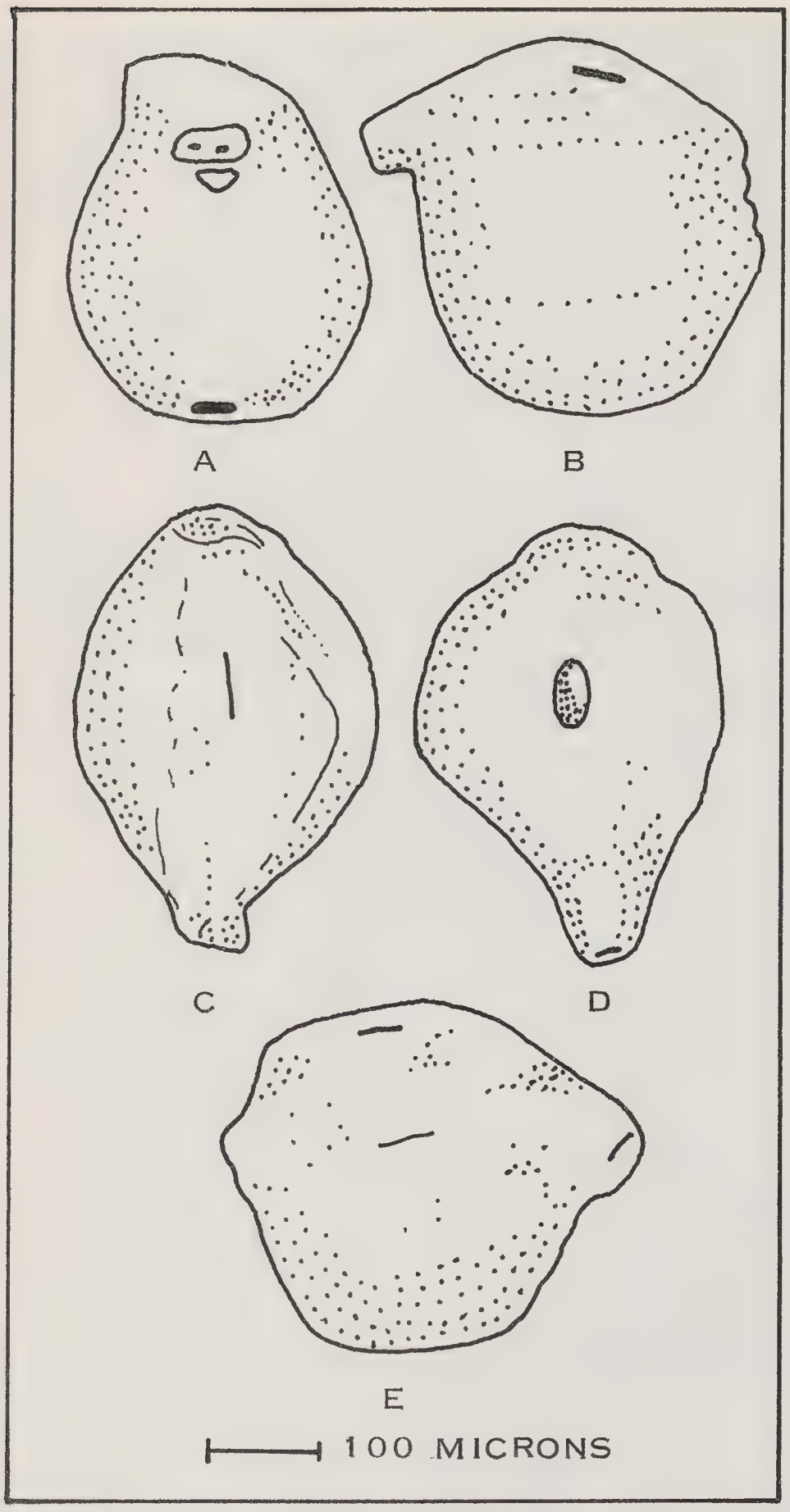


PLATE 2



Text-figure 3. *Voorthuyseniella alabamensis* (Holotype), a, – end view, b, e, – lateral view, c, – dorsal, d, – ventral view. Redrawn from Keij, (1970).

Bandy, instead, tend to substantiate the postulated unconformity (Blow, 1969) at the base of the Red Bluff Formation.

Consequently, the presently determined stratigraphic range of *Voorthuyseniella* in Little Stave Creek may not be a complete range, but merely represents the observed range in the examined section. Text-figure 1 illustrates the range of *Voorthuyseniella* in the Little Stave Creek section and its relative abundance in samples from which it was retrieved.

We have examined a sample from the Red Bluff Formation, St. Stephen's Bluff, which approximates the Red Bluff sample from which Keij obtained a single specimen of this species. Our sample yielded only an additional two specimens of this species. Keij noted that his single Red Bluff specimen was identical to those from the Marianna Limestone Member but was somewhat smaller in size. We agree with this observation.

Bandy regarded the foraminiferal fauna at Little Stave Creek, (samples 56-57), as having been deposited in a predominately warm, shallow sea with relatively little turbidity. Other worldwide occurrences of *Voorthuyseniella* similarly indicate a shallow water environment for this genus, see Huang (1962), Wozny (1966), Kummerle and Gunawardena (1967), Szczechura (1969), and Keij (1970).

The amount of bryozoan detritus in the Little Stave Creek samples is considerable, but varies with the sample. The abundance of *Voorthuyseniella* appears to correlate with the abundance of bryozoan debris present in each sample (see Text-fig. 1) and bryozoa have been recorded in association with *Voorthuyseniella* from other localities as well (Voorthuysen, 1953; Keij, 1965; Wozny, 1966; Szczechura, 1969). Although this relationship is striking in our samples we do not wish to propose any affinity between *Voorthuyseniella* and the bryozoa, other than a similarity of environmental require-

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PLATE 3

VOORTHUYSENIELLA STAVENSIS n. sp.
(Bar = 100 microns)

Figs. 1, 2 Locality #64. (1) Side view (2) Portal view; same specimen.
Figs. 3, 4 Locality #64. (3) Side view (4) Portal view; same specimen.
Fig. 5 Locality #64. Side view.
Fig. 6 Locality #64. Portal view.

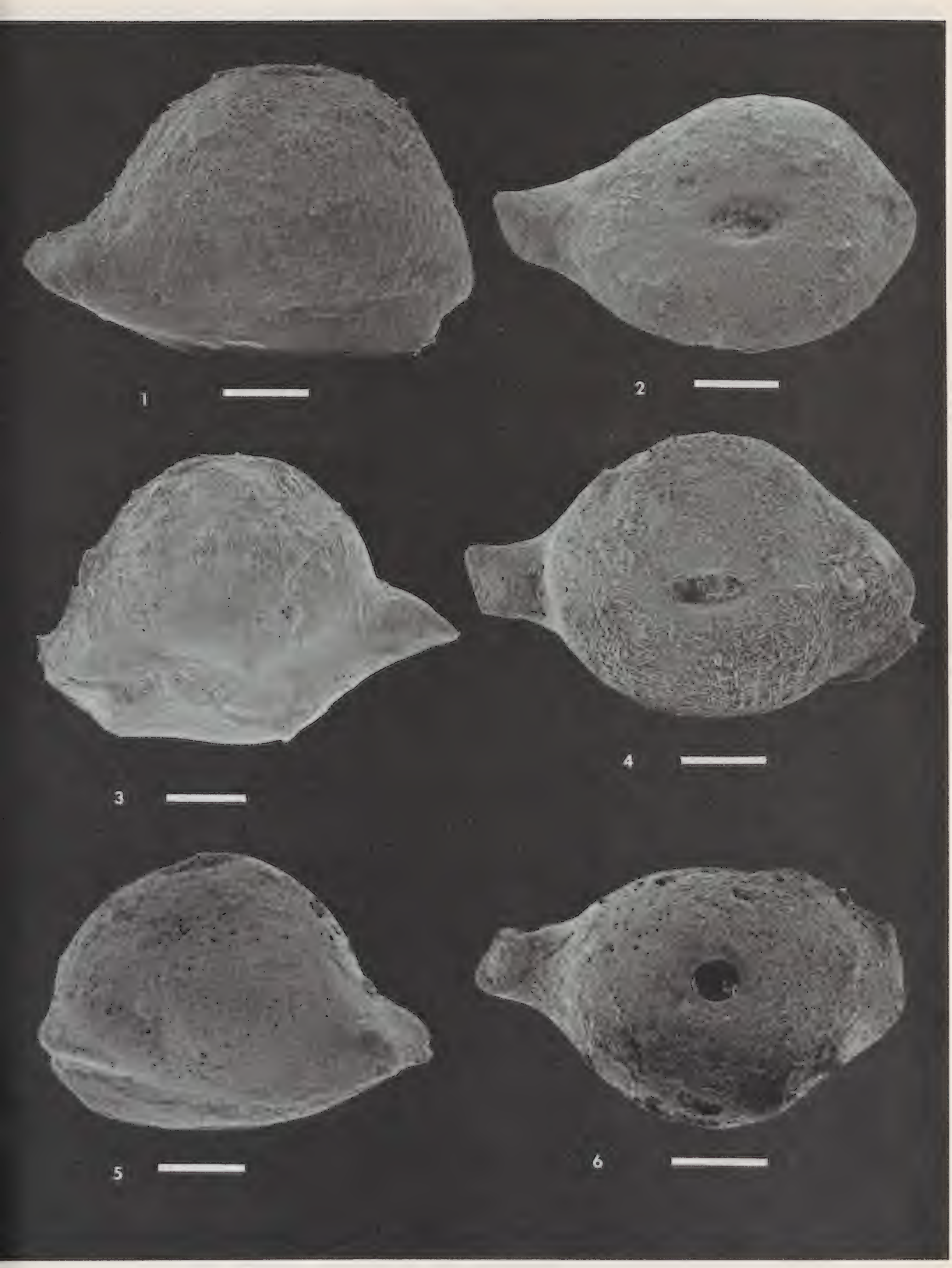
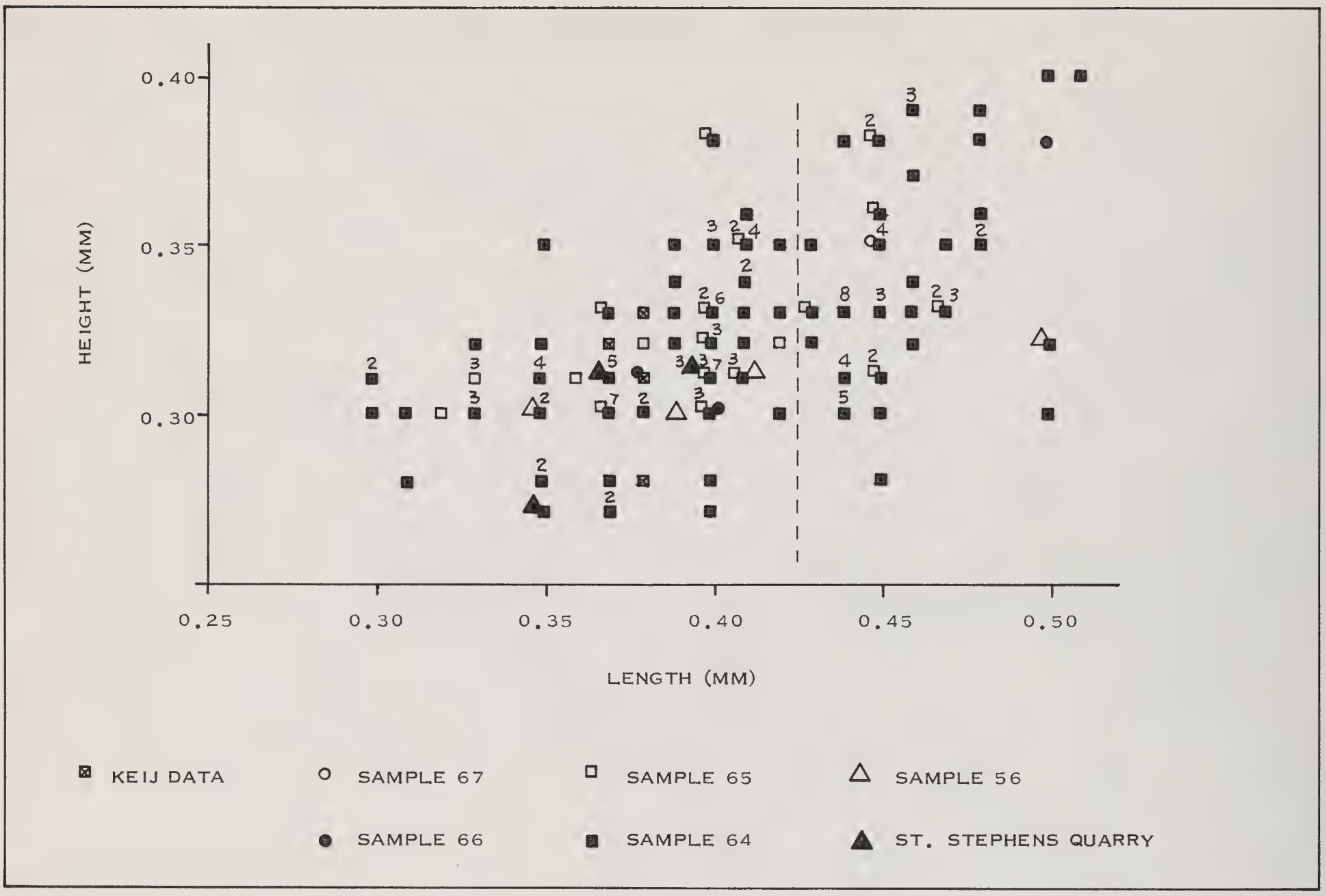


PLATE 3



Text-figure 4. Data plot, length and height, of measurements of *Voorthuyseniella* from Little Stave Creek, and St. Stephens Bluff (dotted line indicates group differentiation).

ments. Systematic affinities to the Echinodermata, Bryozoa, Crustacea, and Foraminifera have been postulated, the strongest being that it has "an approach to the Protozoa" (Szczechura, 1969, p. 82). Keij (1970, p. 480) presents a concise summary of the problematic affinities of this taxon. We feel, as does Keij, that "no positive statement can be made about the systematic position of *Voorthuyseniella.*"

IV. SYSTEMATIC DESCRIPTIONS

Test orientation, morphologic terms and measurement terminology used in this report is based on Szczechura (1969, pl. 2, figs. 1a, 1b) and Keij (1970, text-figure 1).

VOORTHUYSENIELLA ALABAMENSIS Keij, 1970

Plate 1, figs. 1-10; Plate 2, figs. 1-9

Voorthuyseniella alabamensis KEIJ, 1970, Koninkl. Nederl. Akad. Weten., Proc., (Ser. B), vol. 73, p. 487, pl. 8, figs. 1,2.

As the concise article by Keij may not be readily accessible, his description and type figures of *Voorthuyseniella alabamensis* are here reproduced (see Text-figure 3).

"Diagnosis: Tests highly asymmetrical. Tubus surface flat and sloping to one side, with a spout-like extension over "A" lateral aperture. Tubus pore slit-like.

"Description: Test highly asymmetrical, teapot-like in side view because of the spout-like

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PLATE 4

VOORTHUYSENIELLA STAVENSIS n. sp.
(Bar = 100 microns)

Figs. 1-4 Locality #64. Holotype. (1) Side view (2) Portal view (3) Oblique side view with Tubus pore (4) View to 'A' lateral aperture.

Figs. 5, 6 Locality #66. (5) Side view (6) Portal view; same specimen, porta infilled.

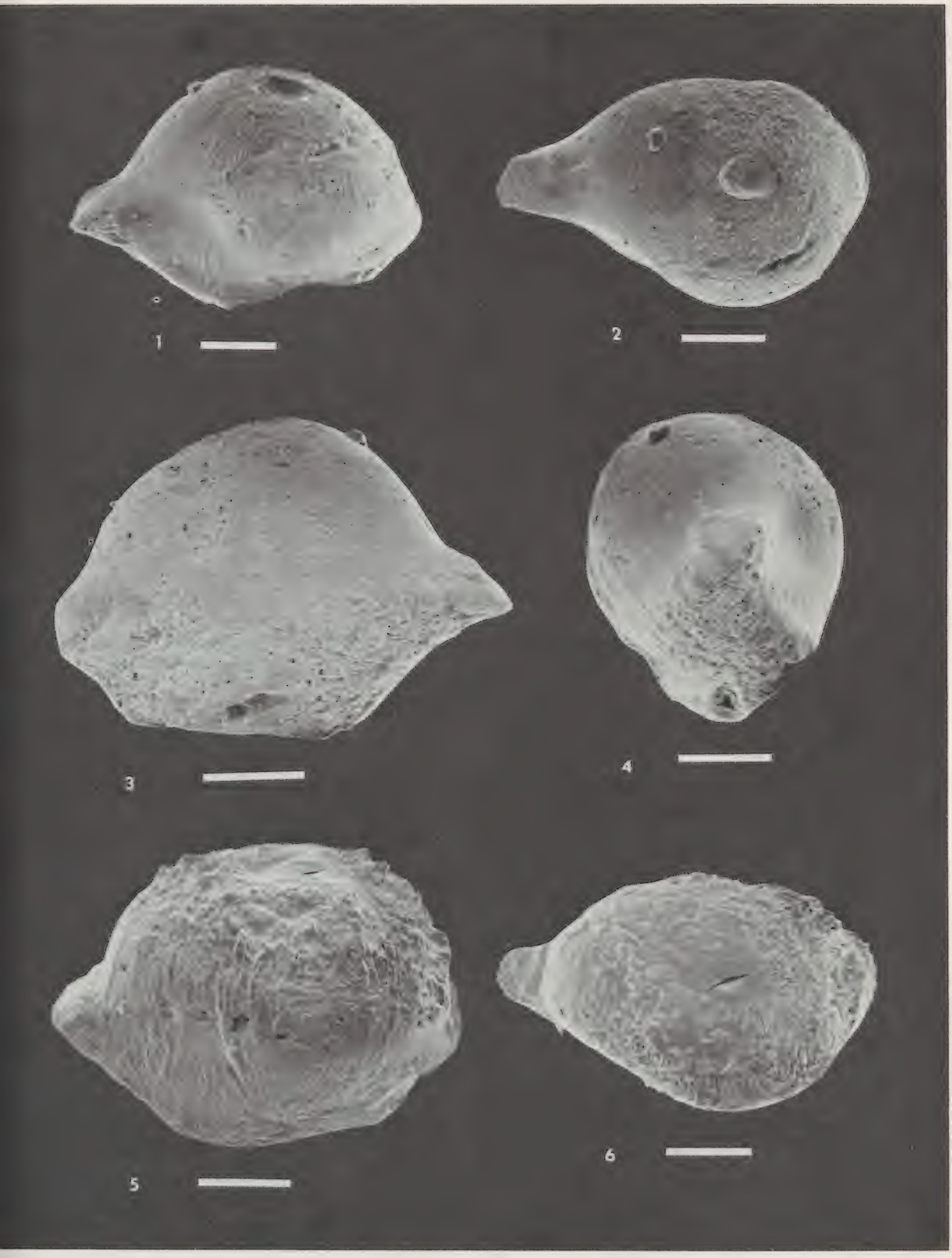
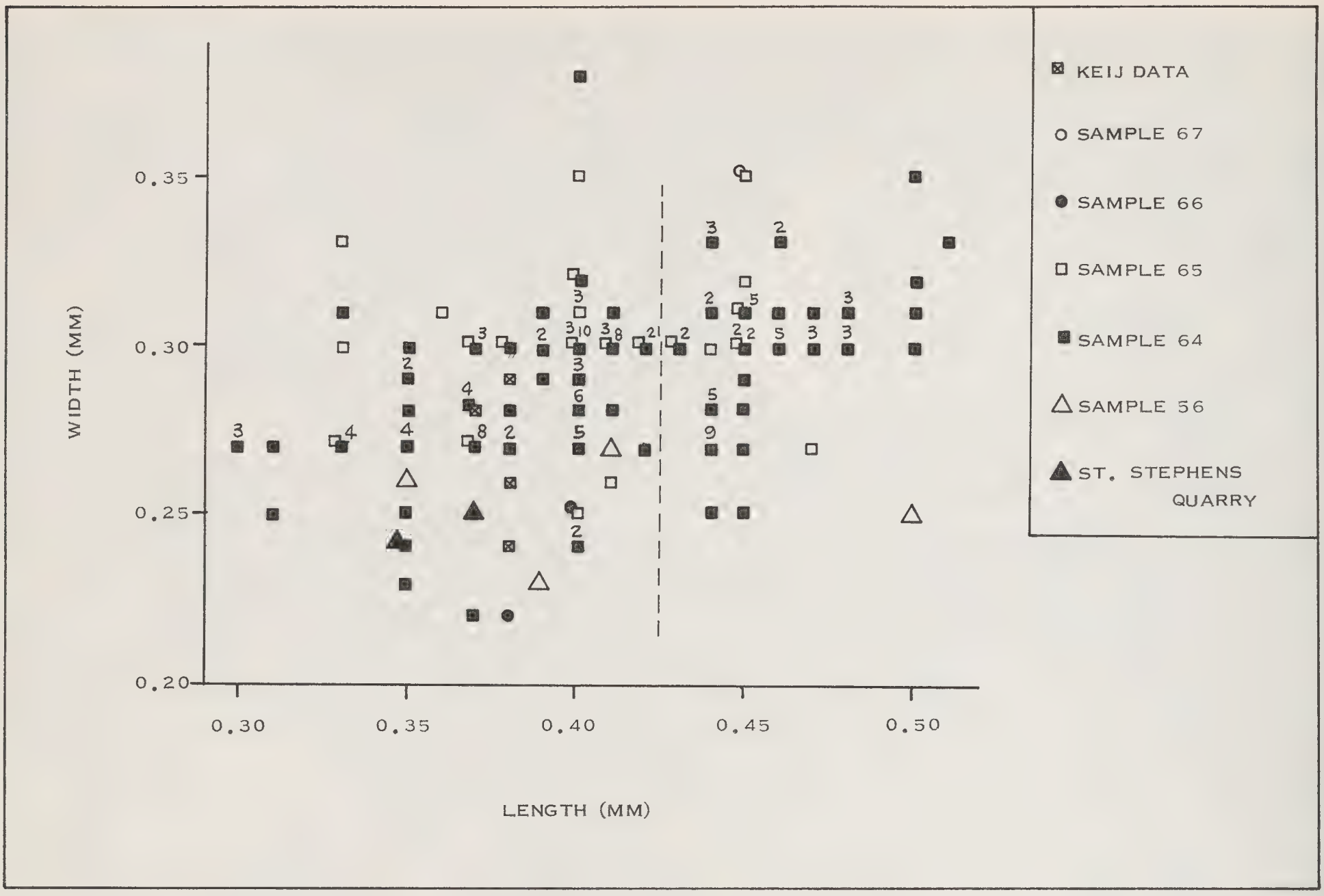


PLATE 4



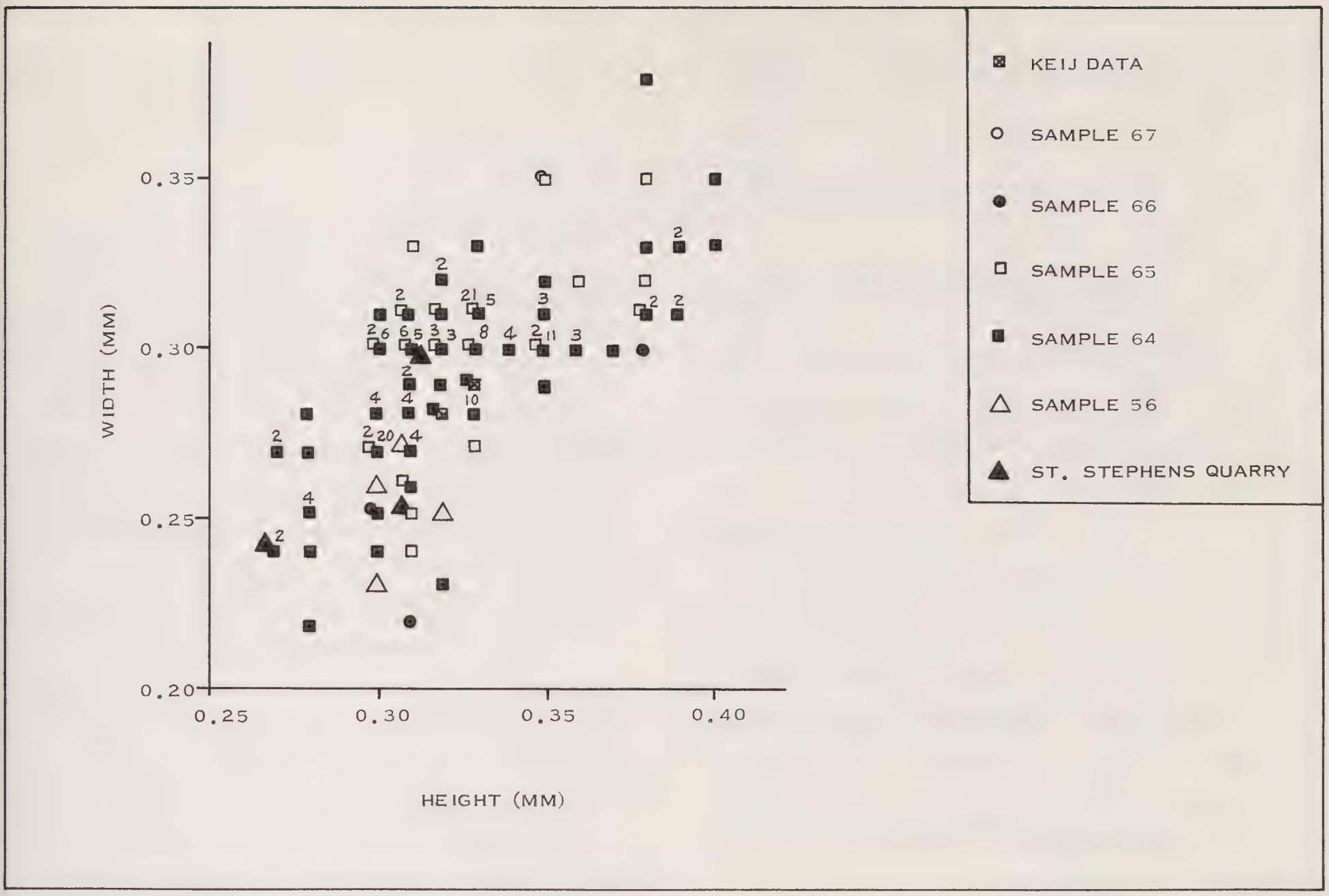
Text-figure 5. Data plot, length and width, of measurements of *Voorthuyseniella* from Little Stave Creek and St. Stephens Bluff (dotted line indicates group differentiation).

extension overhanging the 'A' lateral aperture. Seen from above the test appears to be twisted, no two tests being the same. The test is widest below the middle, the tubus surface is sloping to one side, making the test much higher on one side than the other. Concave areas occur below the highest point and around the lateral extension. The boundary between the tubus and the camera is rather sharply delimited especially near the spout-like extension. The tubus pore is situated below the culmination and is slit-like. The porta is elliptical to circular.

"The 'A' lateral aperture below the overhanging extension is semicircular [fig. A]. The 'B' lateral aperture is circular and lies excentrically in a roughly circular area surrounded by a low and irregular rim [fig. B]. The surface is smooth and shiny." (Keij, 1970, p. 487).

Discussion: Various measurements are plotted on Text-figures 4, 5, 6, for the 175 specimens of *Voorthuyseniella* that we have obtained from Little Stave Creek. The dimensions of Keij's specimens also are included on these text-figures. Two size groupings of the specimens are evident from Text-figures 4 and 5. In Text-figure 4 one size cluster is below 0.425 mm in length, and another cluster has lengths greater than that dimension. A slight increase in test height corresponds to an increase in length, but this is not a marked feature. The specimens of Keij fall within the group of shorter lengths. Text-figure 5 is similar but does not show an appreciable width increase with greater test length. Text-figure 6 shows a distinct cluster in the size range of 0.27-0.32 mm (width) and 0.30-0.35 mm (height) and, although a number of plots fall outside this cluster, the width to height ratio appears to remain constant.

Test dimensions and general appearance allow differentation of two readily recognizable groups. The first group, characterized by a short, compact test, as illustrated on Plates 1 and 2, includes *Voorthuyseniella alabamensis* s.s. The second group has a more elongate, fusiform, or spindle shaped test. Although the height and width are reasonably constant in both groups, the greater test elongation of this group distinctly affects the test appearance (Plates 3 and 4). No biostratigraphic control is indicated as specimens of each group were obtained from the same samples.



Text-figure 6. Data plot, height and width, of measurements of *Voorthuyseniella* from Little Stave Creek and St. Stephens Bluff.

In a problematic taxon such as *Voorthuyseniella,* for which the nature of the organism and its affinities are unknown, we were hesitant to formally separate the two groups by description of another taxon. However, as Keij *(ibid.)* differentiated *Voorthuyseniella cornudensis cornudensis* and *V. cornudensis cruciformis* basically on text elongation, i.e., length-width ratio. It appears prudent to taxonomically separate, in a similar manner, the groups under discussion. *Voorthuyseniella alabamensis* is restricted to include only the group with the shorter, more compact test, and *Voorthuyseniella stavensis* n. sp. is herein proposed for the longer more spindle-like forms.

Keij reports a twisting to the test when viewed from above. This feature is present (Pl. 1, fig. 10; Pl. 2, fig. 5), but is emphasized by asymmetric cameral (main chamber) inflation, which in fact may cause the twisting (Pl. 1, fig. 4; Pl. 2, fig. 1). A similar feature is exhibited by *V. stavensis.*

The test surface of *V. alabamensis* is reported as smooth and shiny by Keij. Instead of being smooth and shiny, our calcareous specimens illustrate solution effects to a varying extent. The greatest amount of test dissolution occurs on the camera, the tubus showing a lesser degree of solution. This feature may indicate a difference in test chemistry, or may be suggestive of a mode of life (tubus area covered?). Tests of *V. stavensis* illustrate similar differential solution. Hypotypes of this taxon are deposited in the Chevron Oil Company Collections, Tulane University Collections, and in the personal collections of the authors.

VOORTHUYSENIELLA STAVENSIS n. sp.

Plate 3, figs. 1-6; Plate 4, figs. 1-6

Description: Test calcareous, unilocular, asymmetrical, sub-hemispherical in side view. Spout-like extension overhangs the 'A' lateral aperture. Test is widest at or just below the middle. Camera shows asymmetric inflation and slight twisting when viewed from above. Tubus surface slopes to one side, with one side of the test higher than the other. Concave areas occur at the base of the

camera and below the spout-like extension. The junction of the tubus and the camera is distinct. Porta is circular to slit-like, variable in shape. 'A' lateral aperture is semi-circular to circular, 'B' lateral aperture is circular and is surrounded by a roughened rim. Tubus pore is elliptical to slit-like. Test surface dull, roughened, and shows solution effects. Length of test greater than 0.425 mm, width and height variable.

Holotype: D. Haman collection; Plate 4, figs. 1-4.

Type locality: Little Stave Creek, Alabama, Bandy (1949) locality #64

Type stratum: Mint Spring Marl Member of Marianna Limestone

Distribution: Bandy (1949) localities 67-62, 56. Little Stave Creek, Alabama. (U. Eocene—M. Oligocene)

Remarks: This new species is differentiated from *V. alabamensis* basically on the length of the test and a generally more spindle-like appearance. This species has not been recorded to date at St. Stephens Bluff in the Red Bluff Formation. Paratypes are deposited in the Chevron Oil Company Collections, Tulane University Collections, and in the personal collections of the authors.

V. ACKNOWLEDGMENTS

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VOORTHUYSENIELLA (PROBLEMATICA) FROM THE PLEISTOCENE OF THE TEXAS CONTINENTAL SHELF

DREW HAMAN and BARRY KOHL

CHEVRON OIL COMPANY, NEW ORLEANS
GEOLOGY DEPT., TULANE UNIVERSITY

A cuttings sample, predominantly composed of mollusk fragments with subsidiary quartz and minor glauconite, was obtained from a well located in the Brazos area of offshore Texas. This sample (approximately 10 ml of dry residue) yielded a rich foraminiferal fauna. Twenty-seven benthonic species, with over 500 individuals, and seven planktonic species with over 30 individuals were recorded. The associated fauna and flora is composed of ostracods, bryozoa, and calcareous algae. The fossil assemblage indicates a middle neritic (50'-300' water depth) environment of deposition and an upper Pleistocene age for the sample.

While examining this sample a representative of the genus *Voorthuyseniella* Szczechura (1969) was retrieved. As little attention has been accorded this genus by New World paleontologists it is believed advisable to publish this note in order that interest be generated in this organism. It is hoped that additional data may help solve the problems of the nature and affinities of the taxon.

Voorthuyseniella was first recorded from the Gulf Coast province by Keij (1970). He recorded *V. occidentalis* Keij from Recent samples from the Stetson Bank and Claypile Bank areas of offshore Texas with a bathymetric range of 27-36 metres, and *V. alabamensis* Keij from the Oligocene of Little Stave Creek and St. Stephens Bluff, Alabama. Haman and Kohl (1976) have discussed the occurrence of *V. alabamensis* in the Alabama Oligocene and extended the range of this form into the Eocene at Little Stave Creek, Alabama. They further established a new species *V. stavensis,* which also occurred in the Oligocene and Eocene section of the same locality. A single test tentatively assigned as *Voorthuyseniella* cf. *irregularis* was recorded by Keij *(ibid.)* from the basal Red Bluff Formation at Shubuta Hill, Wayne County, Mississippi. To our knowledge *Voorthuyseniella* has not been recorded from the Pleistocene of the Gulf Coast area. Only a single specimen of this taxon was obtained and no attempt has been made to describe the form. The purpose of this paper is simply to record the occurrence, paleobathymetric habitat, and faunal relationships.

Test orientation, morphologic terms and measurement terminology is standardized and based on Szczechura (1969, Pl. 2, figs. 1a, 1b), Keij (1970, text-figure 1), and Haman and Kohl (1976, text-figure 2).

VOORTHUYSENIELLA sp. indet.

Plate 1, figs. 1-7; Plate 2, figs. 1-4

Description: Test calcareous, unilocular, nearly spherical. Test is widest at or just below the middle. Test shows symmetrical cameral inflation from above (Pl. 1, fig. 5). Tubus reasonably flat, only slightly higher on one side than the other. Tubus is widest at the middle, tapering slightly to either end (i.e., towards the lateral apertures) (Pl. 1, fig. 4). Porta is circular to sub-circular (0.65 mm x .045 mm) situated in a bevelled depression (0.15 mm x .095 mm). Tubus pore is sub-circular to elliptical (.032 mm x .039 mm), situated midway between the lateral apertures and in line with them. Test twisting or distortion is not evident. Lateral aperture 'A' is circular to sub-circular, irregular, with a flap-like extension over it (Pl. 1, figs. 1, 6, 7). Lateral aperture 'B' is circular, surrounded by a thick flat rim (Pl. 1, fig. 3, Pl. 2, fig. 1) varying in width from .018 mm to .035 mm. No septa are present. As well as can be determined the test is imperforate, but this is difficult to establish as the test has been affected by solution. Test surface under light microscope examination appears striate, but with SEM examination this is shown to be the effect of differential solution. Solution effect does not appear to be restricted to any particular area of the test but is evident over the camera and tubus alike.

Test Dimensions: Max. length 0.31 mm, max. width 0.24 mm, height 0.24 mm.

Locality: Well cuttings sample (580'-610') Brazos area, Block A-28, offshore Texas.

Stratigraphic Level: upper Pleistocene.

Depository: Specimen deposited in the personal collection of D. Haman.

Remarks: This form shows affinities to *Voorthuyseniella occidentalis* Keij, 1970

(Recent, Gulf of Mexico), but differs in possessing a circular to sub-circular porta. Affinities are also shown to *V. borneensis* Keij, 1970 (Recent, South China Sea), by this taxon but it differs in lacking an arched tubus and not having an elliptical porta. If this present taxon does prove to be a variant of either of the above species, it would necessitate a stratigraphic range extension. The validity of using a well cuttings sample to establish an age or age range may be questioned but the infaunal associations and environmental indicators in this sample relative to the knowledge of the worldwide distribution and association of *Voorthuyseniella* lends credence to this occurrence. Keij (1970) and Haman and Kohl (1976) have reviewed the environmental occurrence and faunal associations of *Voorthuyseniella.* Similarities are shown between this form and *V. dingdenensis* Keij, 1970 (middle Miocene, West Germany), but the sinuous junction between the tubus and camera of *V. dingdenensis* is lacking in our specimen. Also, more pronounced lateral apertures are present in the Texas specimen. *V. lageniformis* Szczechura, 1969 (Eocene, Poland), differs in having a less regularly inflated camera and in having a smaller tubus pore. *V. maxima* Keij, 1970 (late Pliocene, Belgium), differs in possessing along slit-like porta.

The authors are indebted to W. H. Akers and B. L. Hill for reading an early draft of the manuscript, to P. Koeppel and D. Greig for assistance with the SEM photography; to Miss M. Carlos for typing the manuscript; and to the Chevron Oil Company for allowing access to the SEM and for publication permission.

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September 15, 1976

VOORTHUYSENIELLA sp. indet.

PLATE 1

Figs. 1-5 (1) View to lateral aperture 'A' (2) Side view (3) View to lateral aperture 'B' (4) View to tubus and tubus pore (5) View to porta. (Bar = 100 microns)

Fig. 6 Lateral aperture 'A'. (Bar = 50 microns)

Fig. 7 Lateral aperture 'A'. (Bar = 25 microns)

PLATE 2

Fig. 1 Lateral aperture 'B'. (Bar = 50 microns) Black outline indicates area of enlargement for fig. 4

Fig. 2 Lateral aperture 'B' looking through camera (main test body) to lateral aperture 'A'. Note absence of septa. (Bar = 10 microns)

Fig. 3 Same as fig. 2. Focused on coccolith rich debris inside camera (main test body). (Bar = 10 microns)

Fig. 4 Enlargement of test surface outlined in fig. 1 showing junction of rim around lateral aperture 'B' with main test body and also the extensive differential solution. (Bar = 10 microns)

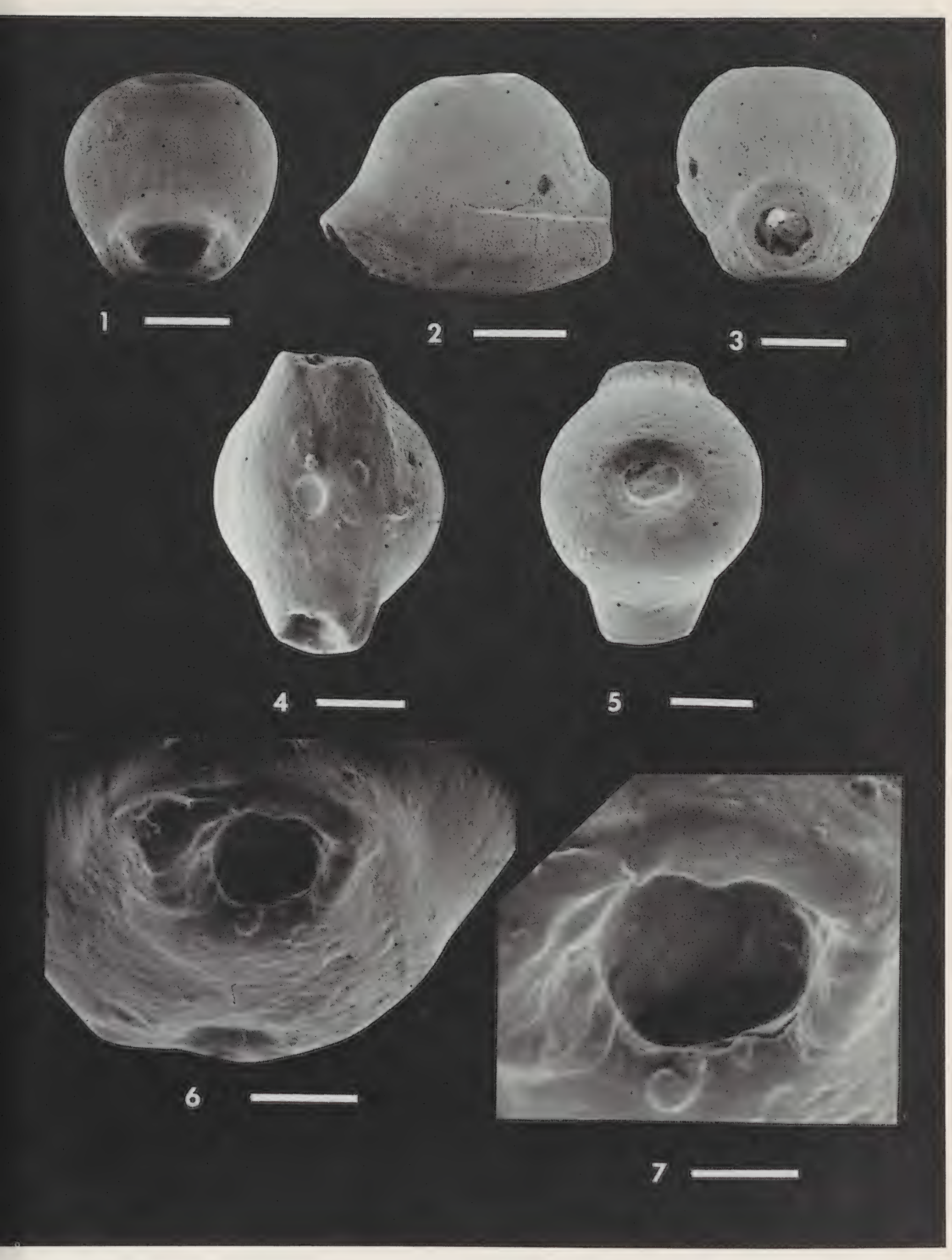


PLATE 1

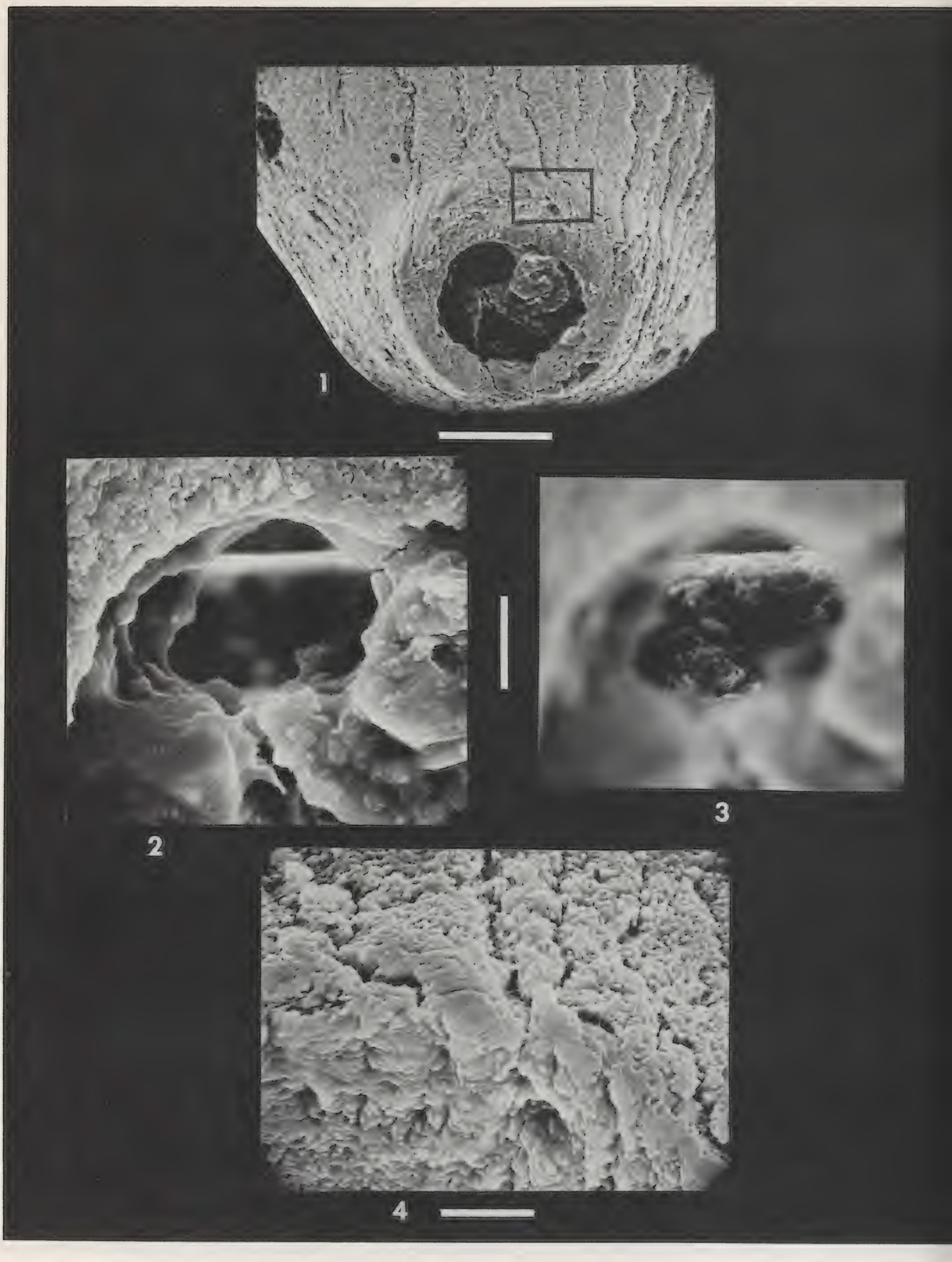


PLATE 2

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION – XIX
ON THE PRESENCE OF *GASTROCHAENA (SPENGLERIA)* (MOLLUSCA: BIVALVIA)

HAROLD E. VOKES
TULANE UNIVERSITY

The Gastrochaenid subgenus *Spengleria* Tryon, 1862, is known, according to the Treatise on Invertebrate Paleontology (1969, p. N699), only from the Recent faunas of the East and the West Indies. It was, therefore, unexpected to find it represented in the collections by a single valve from each of three localities in the Chipola Formation of Calhoun County, Florida. Subsequently, during the preparation of the present paper, it was noted that a Paleocene species described by G. D. Harris as *Gastrochaena cimitariopsis* from the "uppermost layers of the Midway limestone as exposed on the Chattahootchee river at Fort Gaines . . . Georgia" (1896, p. 70 [184], pl. 6 [16], fig. 13) had been questionably referred to *Spengleria* by Dall (1898, p. 824). Examination of Harris' original illustration appears to confirm Dall's conclusion. Harris gave no dimensions for his specimen other than to state that the figure was "twice natural size"; measurement would suggest a specimen about 7.5 mm long and 4.0 mm high. Accordingly it seems probable that *Spengleria* may range throughout the Tertiary of eastern North America.

The Chipola species differs in number of characters from both the West Indian Recent *Gastrochaena (Spengleria) rostrata* Spengler and the Midway *G. (S.?) cimitariopsis* Harris, and is here described.

Genus GASTROCHAENA Spengler, 1783

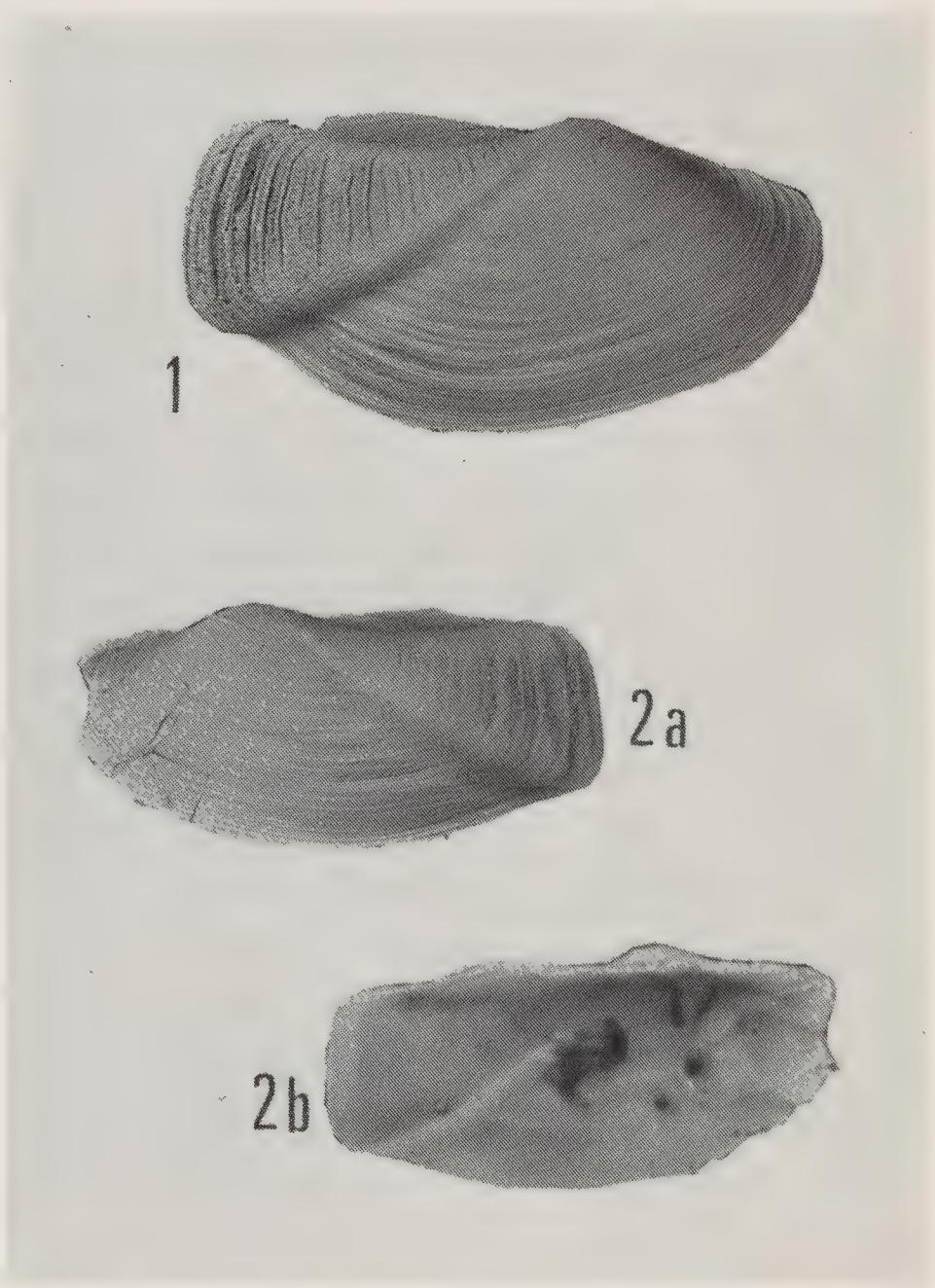
Type species, by subsequent designation, Children 1822, *Gastrochaena cuneiformis* Spengler. Recent, Indo-Pacific.

According to the Treatise on Invertebrate Paleontology, the range of *Gastrochaena* s.s. is "? U.Jur., U.Cret.-Rec., N.Am.-Eu.-circumtrop."

Subgenus SPENGLERIA Tryon, 1862

Type species, by subsequent designation, Stoliczka, 1871, *Gastrochaena mytiloides* Lamarck. Recent, East Indies.

Those species referred to the subgenus *Spengleria* may be distinguished from the typical forms of *Gastrochaena* primarily by having a somewhat raised posterior area of the valves separated from the anterior and ventral areas by an oblique furrow extending from the posterior side of the umbone to the postero-ventral margin. This raised area, which is marked by vertical grooves, is bounded dorsally by a second groove that delimits it from a projecting escutcheon-like postero-dorsal flange. It may also be noted that in all of the specimens available to the writer, the umbones in *Spengleria* are more remote from the anterior end of the valve than they are in *Gastrochaena s.s.*



Text figures. *Gastrochaena (Spengleria) emilyana* H. E. Vokes, n. sp. (1) holotype, USNM 647648, right valve; (2) paratype, USNM 647649, left valve. X 1½.

GASTROCHAENA (SPENGLERIA) EMILYANA H. E. Vokes, n. sp.

Text figures 1-2

Diagnosis: Shell of average size for the subgenus; broadly gaping anteroventrally, elongate-subovate in outline with an almost straight dorsal profile and a broadly convex ventral one. Umbone situated posterior to the anterior third of the length of the valve, slightly projecting and, because of the well-marked postero-umbonal furrows, appearing as if opisthogyrate, although proving on careful investigation to be slightly prosogyrous. Valve surface anterior and ventral to the postero-ventral furrow marked by narrow, concentric growth rugae separated by microscopically fine grooves; superimposed on this ornament is a tendency toward broadly rounded, low concentric undulations that are most strongly marked immediately anterior to the prominent furrow. The posterior end relatively high, and sharply delimited from the rest of the valve. The vertical furrows to be observed only on more worn parts of the surface; the unworn parts being covered by a rather fragile secondary coating (intriticalx ?) that appears almost as if composed of irregularly deposited microscopic aragonitic needles.

Holotype: USNM 647648; length 28.2 mm, height 14.1 mm, diameter (right valve) ca. 5.7 mm; locality TU 830.

Paratype: USNM 647649; length 23.1 mm, height 11.3 mm, diameter (left valve) ca. 4.6 mm; locality TU 547.

Discussion: The holotype specimen comes from the basal bed of the Chipola Formation immediately above its contact with the underlying Chattahootchee Formation. The paratype and a third specimen (from TU 555) come from near the top of the formation as exposed along the Chipola River.

Gastrochaena (Spengleria) emilyana n. sp. is similar to the Recent West Indian *G. (S.) rostrata* Spengler, but may be distinguished from that form by the much more broadly convex anterior and ventral margins that makes the height of the valve of the fossil species equal to almost one-half of its total length whereas in the Recent form the height is equivalent to only slightly more than one-third the total length. In addition, the umbones in the new species are located slightly posterior to the anterior third of the length, in contrast to their position nearer the anterior fourth of the length in *G. (S.) rostrata.* Most striking, perhaps, is the nature of the posterior area, which is somewhat higher above the adjacent shell surface in the fossil species than it is in the Recent one and is marked by the unusual secondary coating or intriticalx (?) that covers the vertical grooves or furrows; in *Spengleria rostrata* there is a somewhat similar deposit that is, however, considerably thinner and as a result depressed into the furrows and rises on the intervening ridges making the vertical ornament visible at all stages of wear.

The specific name assigned to the new species is in recognition of the scientific labors of my dear wife and co-worker, Emily Hoskins Vokes.

LOCALITY DESCRIPTIONS

The three specimens here studied all come from the Chipola Formation of late lower Miocene (Burdigalian) age as exposed in Calhoun County, Florida.

830. Tenmile Creek, basal beds at power line crossing about one mile west of the Chipola River (SE¼ Sec. 12, T1N, R10W).

547. West bank of Chipola River about 2000 feet upstream from mouth of Four Mile Creek (SW¼ Sec. 29, T1N, R9W).

555. East bank of Chipola River about 1000 feet upstream from mouth of Four Mile Creek (SW¼ Sec. 29, T1N, R9W).

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September 15, 1976

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION – XX
A SECOND SPECIES OF *PETRICOLA (PETRICOXENICA)* (MOLLUSCA: BIVALVIA)

HAROLD E. VOKES
TULANE UNIVERSITY

While the writer's recent (Vokes, 1976) description of the new petricolid subgenus *Petricola (Petricoxenica)* and its Pliocene type species, *P. (P.) concoralla,* was in press, a collecting trip was made to the type area of the Chipola Formation in Calhoun County, Florida. At that time a large head of a poritid coral was secured that contained numerous boring and nestling bivalve species, one of which proved to be a second species of *Petricoxenica.* This find prompted a careful examination of the extensive Tulane Chipola collections and four more valves were found, representing three additional localities. This new species, from strata of late lower Miocene (Burdigalian) age, is here described. On the basis of the evidence that it affords, together with additional information obtained from specimens of the subgenotype species found at a second locality (TU 1177) approximately six miles west of the original site, opportunity is taken to modify somewhat the original subgeneric diagnosis. Mr. and Mrs. Hoerle, West Palm Beach, Florida, collected several pairs of *P. (P.) concoralla* from crevices in a porous coralline lime-rock, thus confirming the nestling habit of that species.

Family PETRICOLIDAE Deshayes, 1839
Genus PETRICOLA Lamarck, 1801

Type species, by subsequent designation (Schmidt, 1818): *Petricola costata* Lamarck = *Venus lapicida* Gmelin. Pliocene to Recent, South Carolina to Texas, the Antilles and Caribbean regions.

Subgenus PETRICOXENICA H. E. Vokes

Petricoxenica VOKES, Tulane Stud. Geol. Paleont., vol. 12, no. 1, p. 47.

Type species: *Petricola (Petricoxenica) concoralla* H. E. Vokes,* Pliocene, Caloosahatchee Formation (?), Florida.

*The formal designation of the type species of the subgenus as *Petricolaria [sic] (Petricoxenica) concoralla* was an obvious and regrettable *lapsus* on the part of the writer.

The present species suggests that the heavily pustulate ornamentation is a significant subgeneric character but that the nodes, which appear subsequent to the development of the pustules, are probably of lesser importance than was originally believed. In the Chipola specimens nodes appear to be present only in the latest (gerontic ?) stages of growth.

It is also to be noted that *P. concoralla* attains a size considerably larger than that of the holotype specimen. One pair of valves from TU 1177 has a length of 52.3 mm, height 32.4 mm, and a diameter of 23.0 mm, being 60% greater in length and 77% greater in height. In this specimen, as well as in the four known left valves of the Chipola species, the median left cardinal tooth, which is bifid in the smaller holotype specimen, is entire through broadened and with a median groove on its dorsal surface.

PETRICOLA (PETRICOXENICA) HOERLEAE H. E. Vokes, n. sp.

Text figures 1-3

Diagnosis: Shell elongate-ovate, moderately inflated; umbones low, not prominent, situated at the anterior fourth of the length of the valve; anterior margin rounded, ventral margin broadly and regularly arched and rounding sharply, almost subangulately, to the gently convex posterior end; dorsal margin straight, slightly ascending. A low, relatively inconspicuous groove extending from the posterior side of the umbone to the middle of the posterior end of the valve. Surface ornamented by well-developed pustulation over the entire area except the immediate umbonal region, which is smooth, although one immature example suggests that area was originally also pustulose with the pustules being lost as a result of subsequent abrasion. At about mid-growth the valves are marked by strong concentric growth lamellations, which in the later stages toward the valve margins tend to develop an irregularly nodose outer surface; in the paratype right valve these pustulations becoming elongated toward the postero-ventral edge in a manner suggestive of irregular radial ribbing.

Hinge and interior typical of the subgenus.

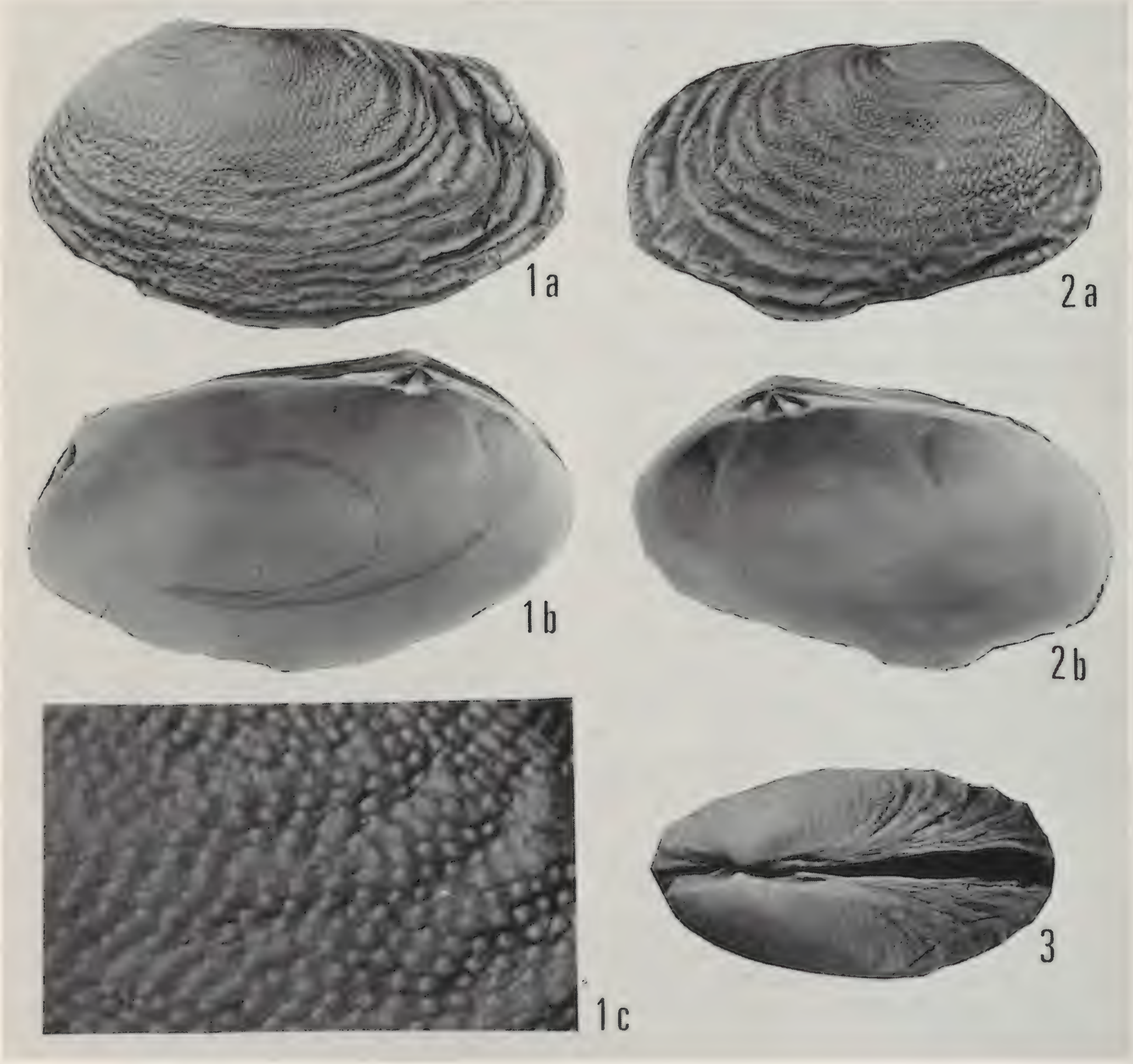
Holotype: USNM 647713; length 41.0 mm, height 24.2 mm, diameter (left valve) 7.9 mm. Locality: TU 548.

Paratype A: USNM 647714; length 36.0 mm, height 20.5 mm, diameter (right valve) 7.0 mm. Locality: TU 459.

Paratype B: USNM 647715; length 31.3 mm, height 15.5 mm, diameter (paired valves) 15.6 mm. Locality: TU 1196.

Remarks: Petricola (Petricoxenica) hoerleae, n. sp., differs most noticeably from *P. (P.) concoralla* Vokes, type of the subgenus, in the absence of the strongly nodose ornament that marks almost the entire surface of the valves in that species; other characters are essentially identical.

The specific epithet for the Pliocene species, *concoralla,* was applied because it was collected from a coral-rich faunal association in a spoil bank pile dredged from a drainage canal. The type lot was not found in an association such as to demonstrate beyond doubt that it was a nestling species, as are so many of the forms assigned to the genus *Petricola.* However, as noted above, subsequent specimens have confirmed that it was a nestler. The small, rather worn, paired valves of Paratype 647715 were found in place in a bored hole in a coral head, thus establishing beyond question the nestling habit for both presently known species of *Petricoxenica.*



Text figure 1, USNM 647713, holotype; a) exterior left valve; b) interior left valve; c) portion of exterior ornamentation, greatly enlarged. Text figure 2, USNM 647714, paratype A; a) exterior right valve; b) interior right valve. Text figure 3, USNM 647715, paratype B; dorsal view, paired valves. (All specimens except 1c magnified X 1½)

It gives me much pleasure to dedicate the present species to Mrs. Robert C. Hoerle of West Palm Beach, Florida, who sent the specimens upon which the present subgenus is based.

LOCALITY DATA

The following Tulane University fossil localities are all in the Chipola Formation, Calhoun County, Florida.

459. Steep bank on east side of Chipola River about 1500 feet above the mouth of Taylor Lake Branch (NW ¼ Sec. 29, T1N, R9W).

548. West bank of Chipola River at bend about 1800 feet south of mouth of Farley Creek (NW ¼ Sec. 29, T1N, R9W).

825. Farley Creek at abandoned mill about ¼ mile west of bridge at Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).

1196. North bank of Farley Creek about 0.8 mile (map distance) east of bridge of Florida Highway 275 (NE ¼ Sec. 29, T1N, R9W).

1177. Caloosahatchee Fm., Mule Pen Quarry, north of Florida Highway 846 and 9.1 miles east of U.S. Highway 41 at Naples Park (SE ¼ Sec. 24, T48S, R26E), Collier County, Florida.

LITERATURE CITED

VOKES, H. E., 1976, A new subgenus and species of *Petricola* (Mollusca:Bivalvia) from the Pliocene of southern Florida: Tulane Stud. Geol. Paleont., vol. 12, no. 1, p. 47-48, text fig. 1.

September 15, 1976

REVIEW

THE STUDY OF TRACE FOSSILS, A Synthesis of Principles, Problems, and Procedures in Ichnology, edited by Robert W. Frey. Published by Springer-Verlag, New York, Heidelberg, and Berlin, 1975, xiv + 562 pp., illus., 8 pp. errata, $57.80

In this work, a comprehensive view of Ichnology is presented in a well organized and coherent textbook approach to this highly significant subdiscipline of paleontology. Each chapter is written by one or more contributors selected for their expertise in the subject and has been reviewed by two or more competent critics. Unlike so many multiple author works, however, each chapter has been extensively edited by Mr. Frey to establish a more-or-less uniform literary style throughout and to insert cross-references to other portions of the text, thus rendering it much more comprehensible.

Part I – Introduction to Ichnology, includes five chapters beginning with the history of Invertebrate Ichnology and its scope and definition. Other portions treat the classification and preservation of trace fossils, and the last deals with false or misleading traces. In Part II, the Geological Significance of Trace Fossils, including the paleontological, stratigraphical, sedimentological, paleoecological and environmental significance of ichnofossils, is considered.

The chapters in Part III – Selected Groups of Trace Fossils include, plant trace fossils, borings as trace fossils and the processes of marine bioerosion, boring microorganisms and microborings in carbonate substrates, traces of predation, vertebrate fossil traces and impressions, vetebrate burrows, unusually large burrows, trace fossils in carbonate rocks, and trace fossils at omission surfaces. In Part IV – Recent Aquatic Lebensspuren, the recent as a potential key to the past is considered, including recent lebensspuren in nonmarine aquatic environments, recent biocoenoses and ichnocoenoses in shallow-water marine environments, and animal traces on the deep sea floor. In Part V – Techniques in the Study of Lebensspuren, the main emphasis is upon methodology, its experimental approaches and the techniques utilized in study of fossil and recent traces.

This volume is very well designed and handsomely illustrated. Only the rather high price of the book will prevent its being widely used as a supplementary text in paleontology curricula. It is a highly useful reference volume in a subject which is becoming increasingly important in paleontological study.

—H.C.S.

A NEW SPECIES OF *BUKRYASTER* FROM THE UPPER CRETACEOUS OF SOUTHEAST OKLAHOMA

ANTHONY KRANCER
EXXON, U.S.A., HOUSTON, TEXAS

A new species of the calcareous nannofossil *Bukryaster* Prins, 1970, occurs in the Ozan Formation of southeast Oklahoma. The Ozan Formation is a member of the Cretaceous Gulfian Series, considered Campanian in age; it consists of marly shales in the lower layers and chalks in the upper layers. The formation has been found to contain a diverse assemblage of marine and terrestrial fossils with cephalopods, oysters, and *Inoceramus* common in several layers. In addition to the megafossils, the Ozan contains a wide variety of ostracods, hystrichosphaerids, acritarchs, dinoflagellates, spores and pollen, and both micro-and megaforaminifera. The most common fossils however, are the coccoliths and associated nannofossils.

Prins (1970) indicated that the nannofossil genus *Bukryaster* Prins (1970) evolved from the genus *Lithastrinus*. Prins did not speculate as to any further evolution from the genus *Bukryaster* but envisioned it as two terminal lineage. It seems likely, with the discovery of the bifid form described here, that *Bukryaster* may have presaged later similar ray patterns in *Discoaster*, although no direct linages are known.

The genus *Bukryaster* is structurally similar to pentalith nannofossils that are mainly restricted to nearshore, warm-water environments (Sullivan, 1964, 1965). These conditions characterize both the Taylor Marl of Texas and the Ozan Formation of southeastern Oklahoma during Campanian times.

A description of the new species follows.

Family SPHENOLITHACEAE Deflandre, 1952

Subfamily LITHASTRINOIDEAE Prins, 1970

Genus BUKRYASTER Prins, 1970

Type species: *Discoaster hayi* Bukry, 1969.

BUKRYASTER OZANENSIS sp. nov.

Plate 1, figs. 1-6

Description: This species is characterized by five rays that bifurcate at the tips. The rays consist of a rectangular calcite ridge at one side and a curved planar area that extends along suture line to the adjacent ray. The curved planar areas form the major portion of the central area. Five sutures are visible in proximal view; on the distal side the ridges are more visible and proceed to a central area that is similar to *Bukryaster hayi* (Bukry) Prins, 1970. In cross-polarized light this species exhibits strong birefringence, having normally two rays extinguished and a third ray showing partial extinction.

Size: Maximum diameter, 7.8-15 microns.

Types, Holotype, OPC 1163-1-NM; Paratypes, OPC-1163-NM-1, OPC-1163-NM-2, OPC-1163-DM-1, OPC-1163-OM-1.

PLATE 1

BUKRYASTER OZANENSIS n. sp.

Figures

1. Holotype; OPC-1163-1-NM, proximal view; SEM phtomicrograph, X 5,500, 14.9 microns.
2. Paratype; OPC-1163-NM-1, transmitted light, proximal view, X 1,200, maximum diameter; 13.5 microns, level NM.
3. Paratype; OPC-1163-NM-2, polarized light, same specimen as in fig. 2.
4. Paratype; OPC-1163-DM-1, transmitted light, distal view; X 900, maximum diameter; 12 microns, level DM, example of variation caused by loss of bifurcating tip.
5. Paratype; OPC-1163-OM-1, transmitted light, distal view; X 1,200, maximum diameter 10.5 microns, level OM specimen shows loss of most of the ridge extensions.
6. Inked outline of figure 5, showing reconstruction of the central area.

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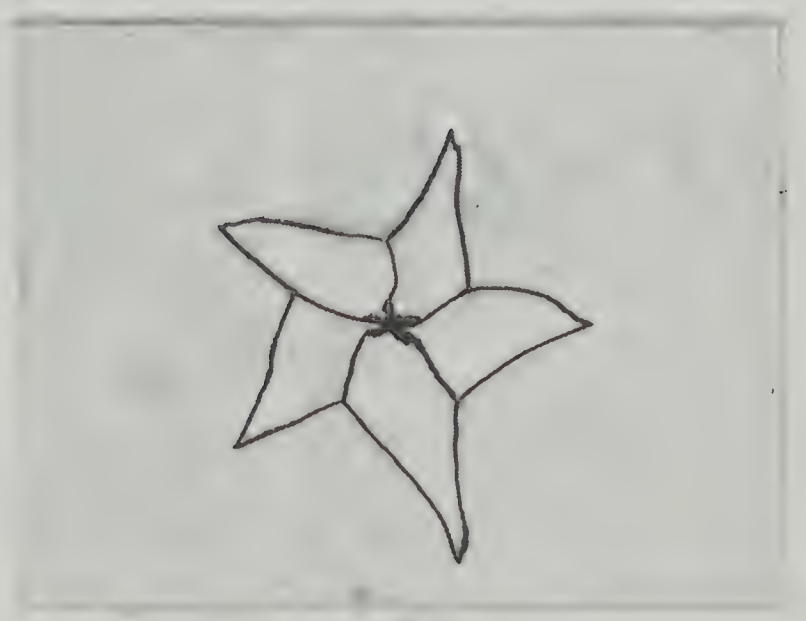

6

PLATE 1

Type locality: Type stratigraphic source, Upper Ozan Formation. Type locality, 1.1 miles west of the Oklahoma-Arkansas state line, on Oklahoma Highway 21, McCurtain Co., Oklahoma; locality and samples, OPC-1163, A-P.

Known range: Campanian.

Remarks: Bukryaster ozanensis differs from *B. hayi* (Bukry) Prins, 1970, in the curvature of the planar areas, *B. ozanensis* having an elliptical curvature rather than the more circular arrangement found in *B. hayi.* The bifurcation of the rays is the most diagnostic difference between the two species. This new species is susceptible to alteration of the rays, which results in two variations noted in the type sample. The loss of the bifurcating tips results in long rays that taper from the center to a point. A second variation results from the loss of the ridges. This produces a pentalith-like form.

ACKNOWLEDGMENTS

The author wishes to thank Dr. David Bukry and Dr. L. R. Wilson for their constructive critism of this report, and Dr. Charles Mankin, Director of the Oklahoma Geological Survey, for making the Scanning Electron Microscope available.

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September 15, 1976

REVIEW

NIAGARA FALLS AND THE GLACIER, by Glenn C. Forrester, with illustrations by William Zannie and John Bjarnov. Published by Exposition Press, Hicksville, New York, 1976, xv + 140 pp., illus., $7.50

That Niagara Falls is a fascinating locality is indisputable. It has fascinated travellers from the early days of European visitors to this continent, beginning with Father Hennepin in 1678 and continuing to the present. However, this little book is both amusing and startling. When one begins a tale, one should begin at the beginning. Mr. Forrester does begin at the beginning; indeed, he begins with the origin of our solar system. He then discusses the origin of Carbon 14 and age dating with Carbon 14 and other radioactive isotopes, proceeds to the origin of primitive life, development of the vertebrates, appearance of man-like creatures in Africa and Asia, and the discovery of America by Columbus, leading to "the French and British and American soldier boys . . . playing musical chairs at Fort Niagara." Major subjects in the second chapter include mountain building, erosion and transportation, sedimentation (preparing the geological pages), fossils and their significance, erosion of the dome, escarpment drainage system, and glaciation. Finally, he begins to discuss the Niagara area. This book is naive and amateurish and is lacking in coherent organization. It does not deserve serious attention.

—H.C.S.

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DINOFLAGELLATE TAXONOMY AND BIOSTRATIGRAPHY AT THE CRETACEOUS-TERTIARY BOUNDARY, ROUND BAY, MARYLAND

DON G. BENSON, JR.
DEPT. OF GEOL. SCI.
V.P.I. AND S.U.
BLACKBURG, VIRGINIA p. 169

EUTREPHOCERAS (NAUTILOIDEA) FROM THE PALEOCENE BEAUFORT FORMATION OF NORTH CAROLINA

RICHARD H. BAILEY
NORTHEASTERN UNIVERSITY, BOSTON, MASS. p. 235

CHARLES LYELL IN LOUISIANA

HUBERT C. SKINNER
TULANE UNIVERSITY p. 243

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DON G. BENSON, JR.[2]
DEPT. OF GEOL. SCI.
V.P.I. AND S.U.
BLACKBURG, VIRGINIA

CONTENTS

Page

I. ABSTRACT 170
II. INTRODUCTION 170
III. METHODS 172
IV. STRATIGRAPHY 176
Monmouth Formation
Brightseat Formation
V. RESULTS OF INVESTIGATION 177
VI. CONCLUSIONS 179
VII. NOMENCLATURE AND TAXONOMY 179
VIII. ACKNOWLEDGMENTS 179
IX. SYSTEMATIC PALYNOLOGY 180
X. REFERENCES CITED 229

ILLUSTRATIONS

Figure 1 Sketch map of sample locality 171
Figure 2 Columnar section, Round Bay, Maryland 172
Figure 3 Frequency of Dinoflagellates in the Monmouth and Brightseat Formations, Round Bay, Maryland 174
Figure 4 Stratigraphic distribution of Dinoflagellates in the Monmouth and Brightseat Formations, Round Bay, Maryland 175
Table 1 Diagnostic Paleocene Species, Round Bay, Maryland 178
Plate 1 199
Plate 2 201
Plate 3 203
Plate 4 205
Plate 5 207
Plate 6 209
Plate 7 211
Plate 8 213
Plate 9 215

(continued next page)

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Plate 10 217
Plate 11 219
Plate 12 221
Plate 13 223
Plate 14 225
Plate 15 227

I. ABSTRACT

Dinoflagellate assemblages from the Monmouth (Cretaceous) and Brightseat (Paleocene) formations are described. The dinoflagellate assemblages support the placement of the Monmouth Formation by previous workers in the Maestrichtian Stage, and the assignment of the Brightseat Formation to the Paleocene series.

The Cretaceous-Tertiary boundary is characterized by a sudden change in the content of the dinoflagellate assemblage. Based on this sudden change the boundary is interpreted as a paraconformity.

Changes in the dinoflagellate assemblage within the Monmouth Formation of this area form the basis for the establishment of three provisional zones which may serve as a framework for future work in this region.

The dinoflagellate assemblages contain 35 genera and 66 species of which two genera and eight species are described for the first time. The new genera are *Cyclapophysis* and *Diversispina.*

II. INTRODUCTION

The Cretaceous-Tertiary boundary of the Atlantic Coastal Plain has been the subject of several investigations since Clark (1898) published his pioneer work on the Upper Cretaceous formations of New Jersey. Controversary has arisen as to the nature of the boundary with some studies supporting a gradational (conformable) relationship (Olsson, 1960, 1963; Jordan, 1963) and others an unconformable relationship (Minard *et al.,* 1969). Most work has been done on formations in the New Jersey and Delaware Coastal Plain. Of the little work done on the Maryland Coastal Plain, most has been concentrated on the eastern shore region.

The objectives of the present study are: to describe the dinoflagellate assemblages in the Monmouth and Brightseat formations; to determine the stratigraphic distribution of dinoflagellates relative to the Cretaceous-Tertiary boundary; and to contribute to an effort by the palynological group at V.P.I. & S.U. to establish a standard dinoflagellate succession for the Atlantic Coastal Plain.

Although the section under investigation affords one of the better exposures of the boundary and associated formations in Maryland, it has been leached and contains no calcareous fossils. The lack of calcareous fossils in this and other sections frequently precludes accurate correlations. In cases like this a palynological approach often is the only feasible paleontological method for accurate dating.

The biostratigraphic utility of dinoflagellates on the Grand Banks has been demonstrated (Upshaw *et al.,* 1974) and the establishment of a standard dinoflagellate succession for use in the Atlantic Coastal Plain would be of great value in correlating coastal plain and continental shelf sediments when offshore drilling begins along the Atlantic Coast.

Many studies have been carried out on Cretaceous and Paleocene dinoflagellate assemblages throughout the world. Few of these investigations have studied the dinoflagellate transition across the Cretaceous-Tertiary boundary. In addition, the utility of some previous investigations is diminished by poor stratigraphic definition of sample localities. However, the studies of Drugg (1967) on the Cretaceous-Tertiary boundary in Southern California, Stanley (1965) on the Cretaceous-Tertiary boundary in western South Dakota, and Zaitzeff and Cross (1966) on the Navarro Group in Texas were useful in the present work.

No reports on the palynology of the Monmouth Formation in Maryland have been published; however, Waanders (unpublished Ph. D. dissertation, 1974) has investigated pollen and spores and figured

some dinoflagellates from the Monmouth Group, Monmouth County, New Jersey. No comparison can be made between the work of Waanders (1974) and this work because Waanders did not present ranges for his dinoflagellates.

Two other investigations are in progress on the Atlantic Coastal Plain, which are

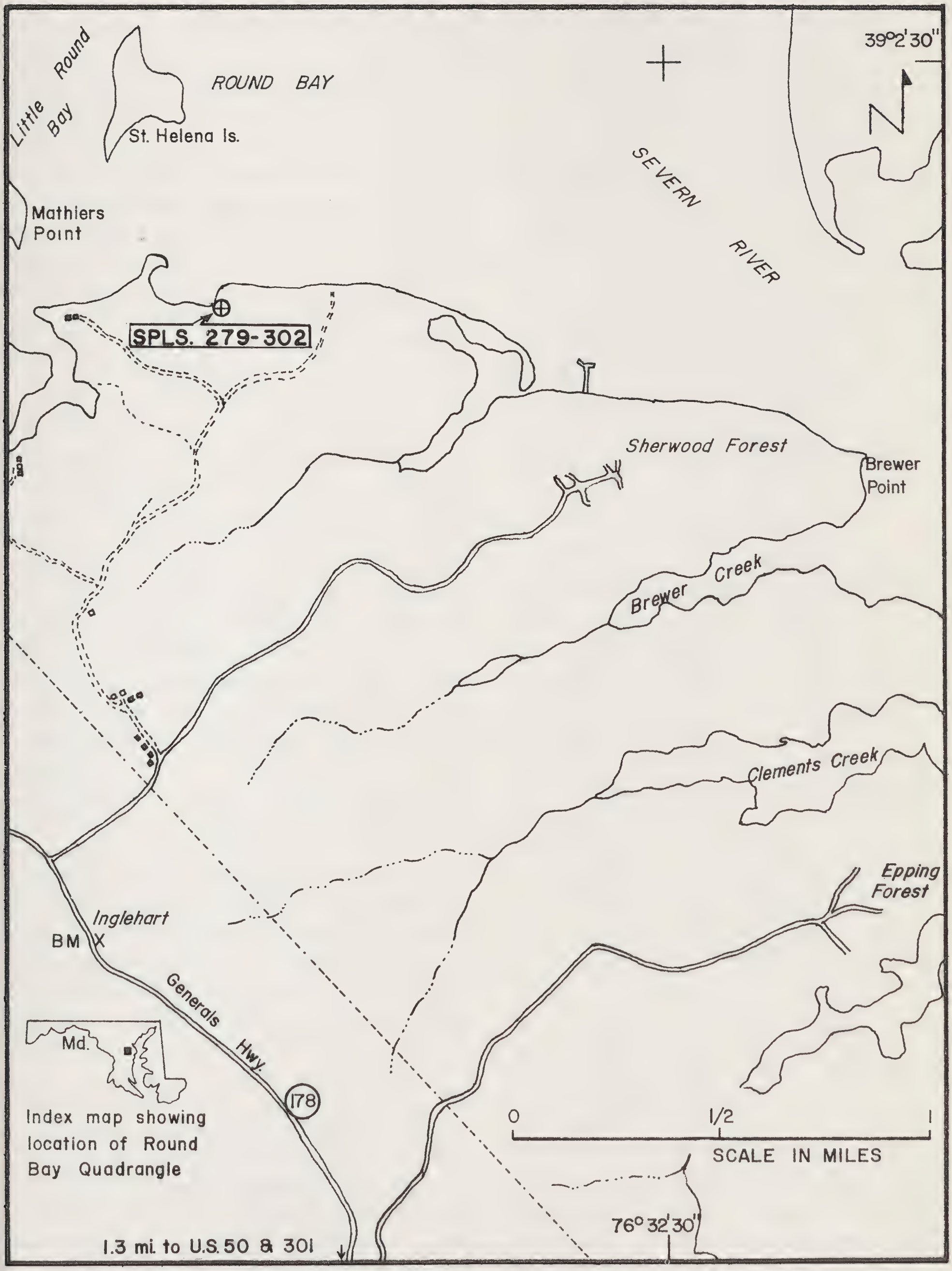

Figure 1. Sketch map showing sample locality.

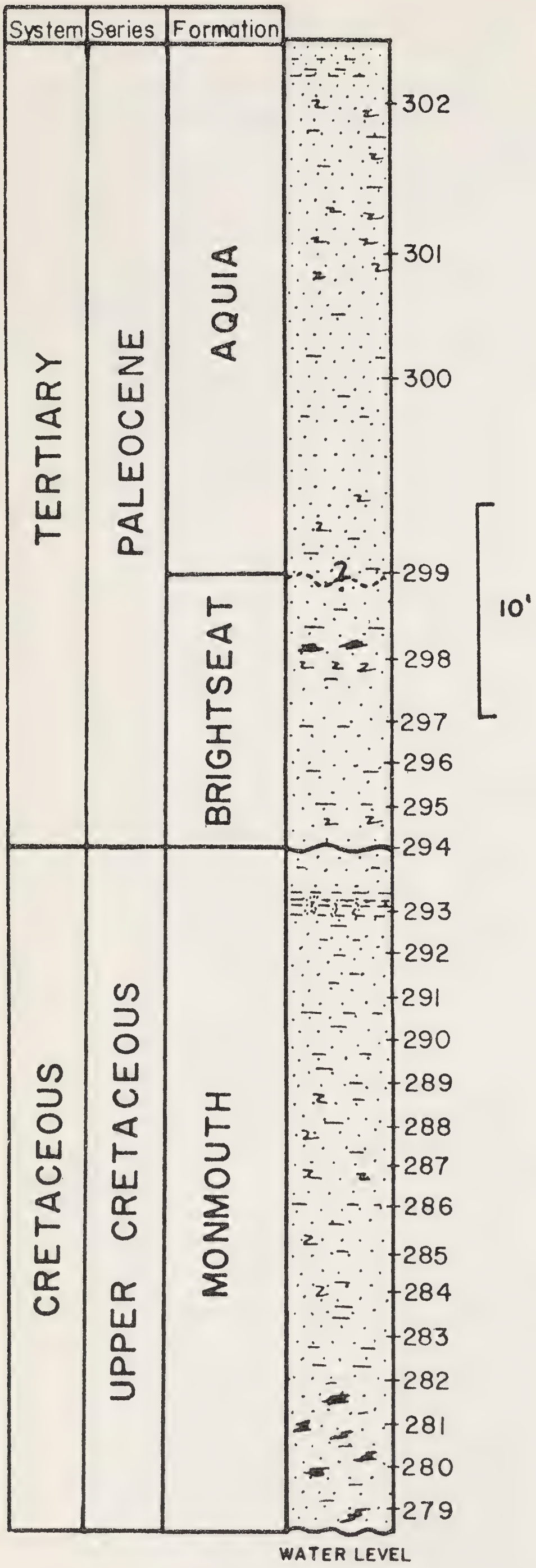

Figure 2. Columnar section Cretaceous and Tertiary sediments, Round Bay, Maryland.

pertinent to the present study. Fred May of the U. S. Geological Survey is completing a study on the dinoflagellates of the Monmouth Group, New Jersey, and Barbara Whitney of the University of Washington at Seattle, is investigating dinoflagellate assemblages on the Monmouth and Brightseat formations in Maryland from locations at least twenty miles west and north of the author's study section. The results of these investigations are not as yet complete thus no comparison between distributions of dinoflagellates in those studies and the present work can be drawn. A publication by Groot and Groot (1962) on the Brightseat Formation treated pollen and spores. They included photographs of some dinoflagellates, but did not describe any species.

III. METHODS

Location and Sampling Procedures

The section studied was shown to the author by James P. Minard of the U. S. Geological Survey in July, 1974. It is located on the southern bank of Round Bay on the Severn River, Anne Arundel County, Maryland. The location is shown on Figure 1, its coordinates being 76° 33' 5.3"W, 39° 02' 2" N. Two sections, approximately two hundred feet apart are exposed at this locality: an easternmost northfacing bluff, and a westernmost exposure in an erosional ravine. For this study the latter section was sampled since it appeared to be less affected by weathering and slumping than is the bluff exposure.

Before sampling, the outcrop was cleaned of weathered sediment. Samples were taken at two-foot intervals beginning at the high water level of the Severn River. Twenty-four samples were taken at positions shown to scale on the section in Figure 2. The

EXPLANATION

- Sand
- Silt, clay
- Glauconite
- Lignite
- 302 Sample location (298-302 barren)

sampling interval above sample 297 was greater than two feet because of vegetation cover and extensive weathering of the exposure. Approximately 750 cubic centimeters of sediment was collected for each sample with clean equipment to prevent contamination. The samples were placed in labeled plastic bags for storage and transportation. Nineteen contained dinoflagellates.

Sample Processing

Samples were disaggregated by crushing with a glass stirring rod in a plastic beaker following an overnight soaking in distilled water. Approximately 100 cubic centimeters of sediment was processed as follows:

1. Overnight exposure to distilled water to facilitate disaggregation.
2. Treatment with HC1 to remove calcareous material; wash with distilled water.
3. Overnight exposure to HF; wash with distilled water to remove dissolved silicates.
4. Resuspension of sediment in distilled water; decantation of fine sediment following 15 sec. of settling to remove coarse sand fraction.
5. Treatment of the fine sediment with hot concentrated HC1 to facilitate disaggregation of clay; wash with distilled water.
6. Oxidation with acidified commercial NaClO to remove susceptible organic material; wash with distilled water.
7. Treatment with NH_4OH to adjust pH to neutrality and facilitate clay removal.
8. Filtration through 20 micron mesh stainless steel sieve. The filtrate is discarded, and the retained material saved for further processing. The sieve was cleaned by an ultrasonic cleaner between samples.
9. Following treatment with glacial CH_3COOH and centrifugation, the samples were treated with $(CH_3CO)_2O$ acidified with H_2SO_4 for 15-20 minutes in a water bath at 90-100° C. The acetylation darkened the palynomorphs for microscopy and removed additional unwanted organic material. The samples were cooled and centrifuged successively with CH_3COOH and distilled water.
10. Palynomorphs were separated from inorganic debris by heavy liquid separation in $ZnBr_2$, sp. gr. 2.0, and centrifuged for 15 minutes.
11. The organic residue was filtered again as in step 8 to remove fine debris.
12. The palynomorphs were placed on a coverslip in glycerine jelly on a warming table, and allowed to dry for 20-30 minutes. The coverslip was then affixed by glycerine jelly onto the 1 X 3 inch glass microslide.
13. After about one week, the excess glycerine jelly was removed from the edge of the coverslip and the preparation was sealed with clear nail polish.

The slides are stored in slide box AN in the V.P.I. & S.U. Paleontological Collection. Each slide is inscribed with the sample numbers shown in Figure 2, slide box series AN, and the slide number.

Counting Procedures

Four slides were prepared for each sample and were scanned to establish the species of dinoflagellates present. Following completion of the taxonomic portion of the study the slides were scanned across uniformly spaced traverses to count the number of specimens. An average of two to three hundred dinoflagellate specimens were counted for each sample. The exact number of specimens counted, is summarized in Figure 3.

The relative abundance of dinoflagellate species is broken down as follows:

1% = very rare
4-5% = rare
5-25% = common
25% = abundant

Specimens observed during the course of microscopy but not during counting are designated by the letter "X".

Specimen Location

The location of the holotypes and figured specimens is given in millimeters to the right (R) and up (+) from the lower left corner of the coverslip.

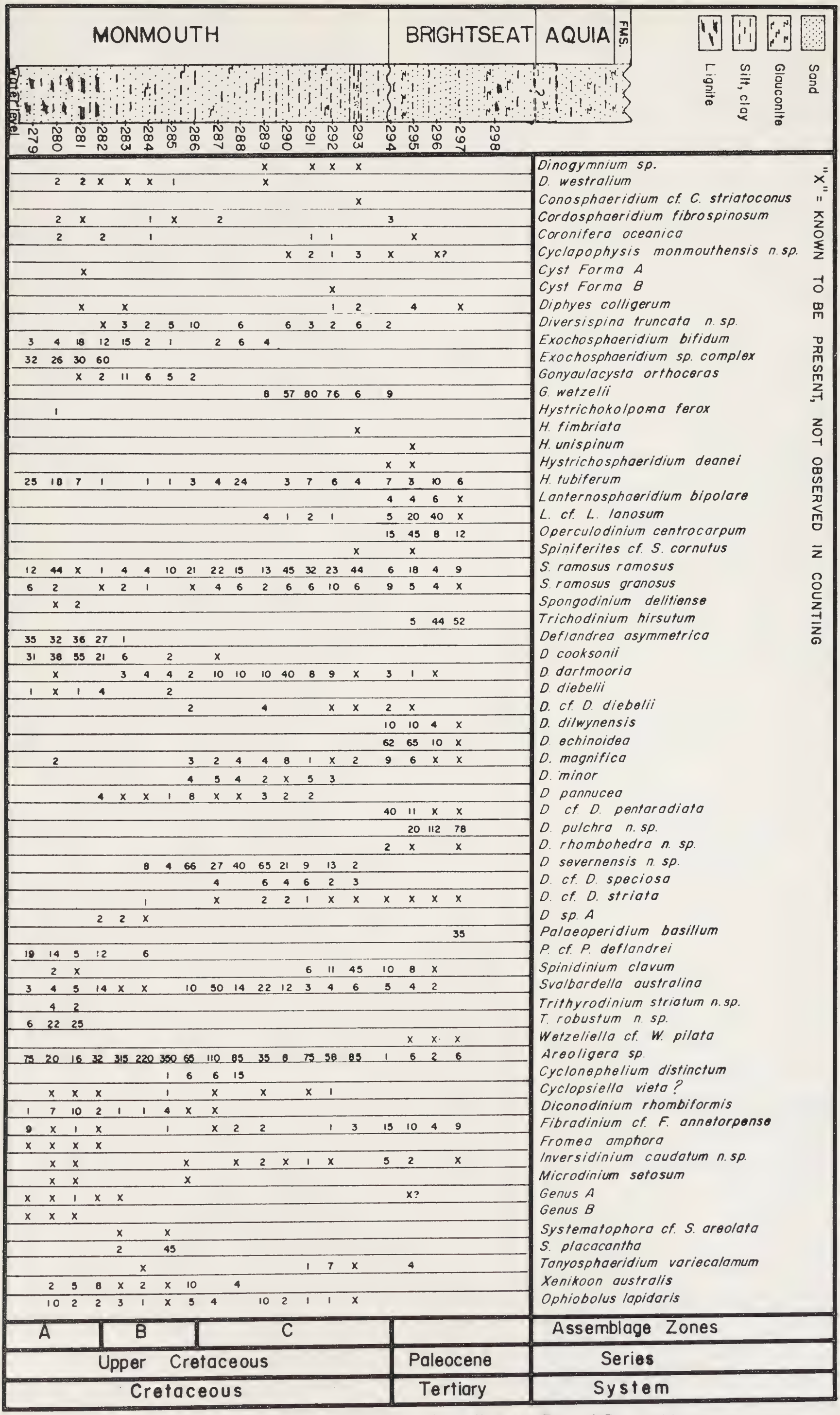

FIG. 3. Frequency of dinoflagellates, Round Bay, Md.

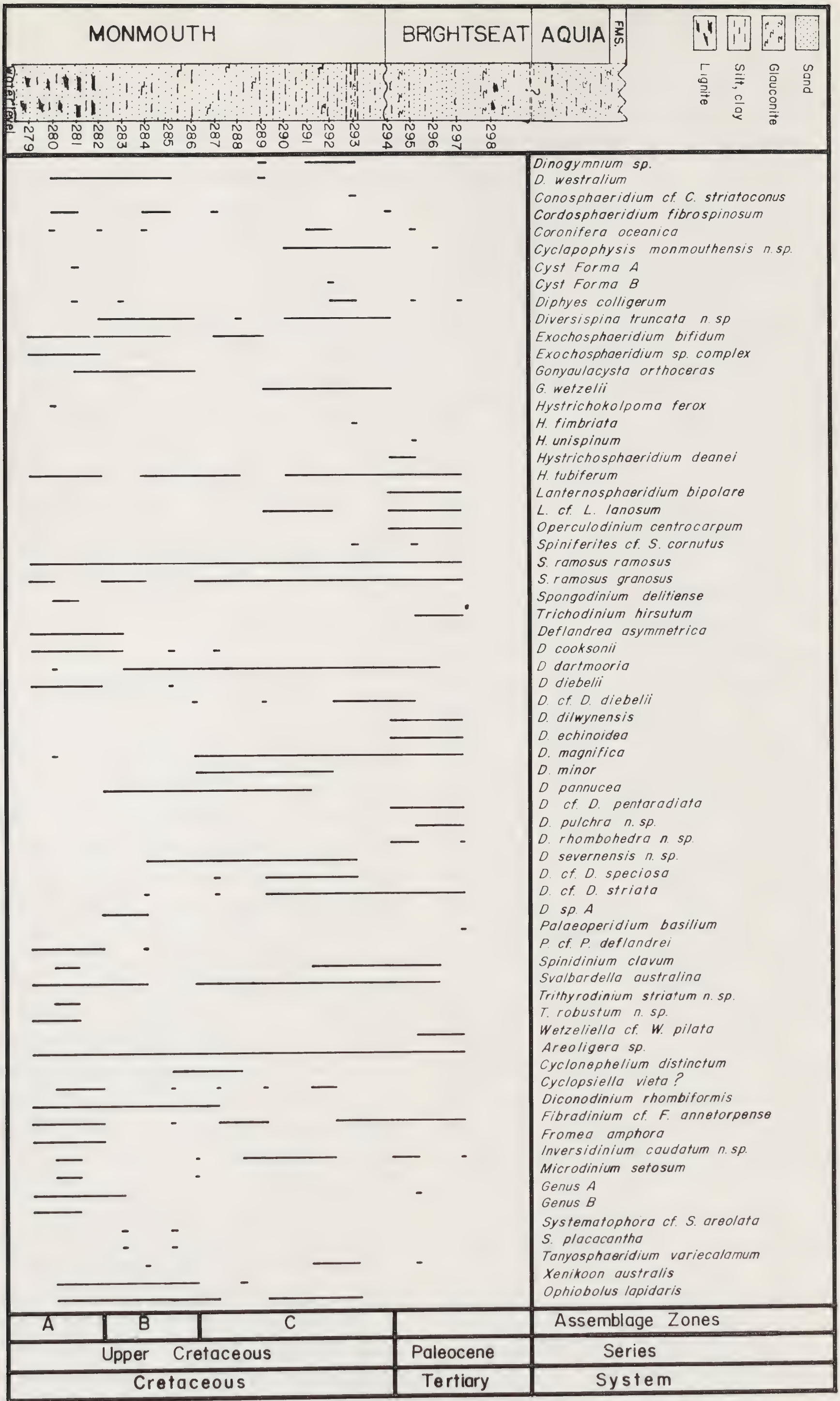

FIG. 4. Stratigraphic distribution of dinoflagellates, Round Bay, Md.

IV. STRATIGRAPHY

Monmouth Formation

The Monmouth Formation was named by Clark (1897) for exposures of Late Cretaceous glauconitic, silty sands located in Monmouth County, New Jersey. The Monmouth Formation was divided by Clark into three units: the basal Mt. Laurel sands, the Navesink marls; and the Redbank sands. These units were later elevated to formational rank and the Tinton Formation was separated from the uppermost Redbank (Weller 1905, 1907). The Mt. Laurel, Navesink, Redbank, and Tinton formations, although recognizable in New Jersey as the Monmouth Group, do not have the distinctive lithologies in Maryland where the name Monmouth Formation is used. Recent mapping by Minard (1974) near Betterton on the eastern shore of Maryland has, however, demonstrated the presence of the Mt. Laurel Formation. Minard (1974) states that a coarse glauconitic bed is "startingly similar to the coarse bed at the top of the Mt. Laurel and at the base of the Navesink" (p. 24); however, the lithologic evidence was insufficient to distinguish the presence of the Navesink Formation from the Mt. Laurel Formation. It remains to be seen if these lithologic units can be traced laterally and extended to the western shore of the Chesapeake Bay since Clark (1916) stated that the separation of the Monmouth Formation into members of more than just local extent in Maryland was not possible.

The Monmouth Formation in Maryland strikes northeasterly and dips to the southeast at 20 to 25 feet per mile. The thickness ranges from zero to 100 feet, the lower values tending to be more southwesterly and up dip in distribution. To the southwest along the strike, the Monmouth Formation rests on progressively older Cretaceous units (Clark, 1916) in an overstepping relationship. In the Round Bay region along the western edge of the Chesapeake Bay in Maryland, the Monmouth rests disconformably on the Matawan (?Merchantville) Formation of Campanian age; whereas, to the southwest near Brightseat, Maryland, it rests disconformably on sediments of the Lower Cretaceous Potomac Group (Clark, 1916).

The Monmouth Formation is overlain by strata of Paleocene, ?Eocene, and Miocene age in Maryland (Clark, 1916; Little, 1917; Vokes, 1957; Cooke, 1952) and it appears that in Maryland there can be little doubt as to the unconformable nature of the Cretaceous-Tertiary boundary. The extent of the hiatus decreases to the northeast with sediments of Paleocene age present near Betterton, Maryland (Minard, 1974). To the southwest, in Prince Georges County, overlying the Monmouth Formation are sediments as young as the Miocene Chesapeake Group (Cooke, 1952).

The Monmouth Formation is considered to be Maestrichtian in age based on the presence within it of the *Exogyra costata* and *E. cancellata* Zones (Stephenson *et al.*, 1942). That age assignment has been supported by Mumby (1962) on the basis of foraminiferal data.

Brightseat Formation

The Brightseat Formation was named by Bennett and Collins (1952) for a dark gray, micaceous, sandy clay unit of Paleocene age located near Brightseat, Prince Georges County, Maryland. The exposures of the Brightseat Formation are scattered and relatively thin (eight to ten feet). In the subsurface, thicknesses of 50 to 75 feet have been reported (Bennett and Collins, 1952). The contact with the underlying Monmouth Formation was observed by Bennett and Collins only at one locality; however, they suggested that it is unconformable based on the presence in the basal Brightseat of pebbles, reworked Monmouth Formation fossils, and the abrupt nature of the contact. The Brightseat Formation has been placed in the *Globigerina daubjergensis - Globorotalia compressa* Zone of the Danian stage by Hazel (1968), based on ostracodes. Hazel (1968) stated that the Brightseat Formation is equivalent to Clark and Martin's (1901) Zone 1 of the Aquia Formation. The upper contact of the Brightseat Formation with the overlying Aquia was considered by Bennett and Collins (1952) to be discon-

formable. However, Nogan (1964) and Drobnyk (1965) throught that the contact was gradational. Hazel (1969), on the basis of ostracode studies, supported a disconformable relationship.

V. RESULTS OF INVESTIGATION

Biostratigraphy

Of the 66 species described in this study, twelve are restricted to the Paleocene, 35 restricted to the Cretaceous sediments, and 19 cross the Cretaceous-Tertiary boundary. The distribution of the fossils throughout the section is summarized in Figure 4. Several species including *?Achomosphaera* sp., *?Oligosphaeridium* sp., *Membranosphaera* sp. and *Cladopyxidium* sp. were not studied due to problems of preservation and low recovery. Several species are apparently reworked. Cases of probable reworking are noted in the Systematic Palynology section.

Zonation

The author feels that provisional zones can be proposed for the Monmouth Formation, even though only a single section was studied. The zones are provisional since further work probably will extend the range of some of the species involved. They were established by utilizing the first or last appearance of a species, or restriction of a species to a particular zone. The zones are informally named, in ascending order: Monmouth Assemblage Zones A, B, and C. The floral characteristics of Zones A, B, and C are summarized in Figure 4.

Monmouth Assemblage Zone A is not defined basally. Reconnaissance examination of samples provided to the author by Jim Minard (U. S. Geological Survey) from exposures on the eastern bank of the Severn River approximately 1.5 miles northeast of the Round Bay locality, at which the base of the Monmouth Formation is exposed indicates that the base of zone A coincides roughly with the base of the Monmouth Formation. *Trithyrodinium robustum* n. sp. and *Spongodinium delitiense* exhibit local extinction within the zone. The top of the zone is characterized by the last appearance of *Fromea amphora.*

Monmouth Assemblage Zone B is distinguished by the first appearance of *Deflandrea pannucea, Deflandrea* cf. *D. speciosa,* and *Deflandrea* sp. A at its base and the local extinction of *Deflandrea cooksonii* and *Gonyaulacysta orthoceras* at its top.

The base of Monmouth Assemblage Zone C is marked by the first appearance of *Deflandrea* cf. *D. diebelii, Deflandrea minor,* and *Lanternosphaeridium* cf. *L. lanosum. Dinogymnium* sp. and *Cyclapophysis monmouthensis* gen. et sp. nov. are distinctive species first seen within the zone. *Deflandrea minor, Deflandrea severnensis* n. sp., *Deflandrea pannucea* and *Dinogymnium westralium* become locally extinct near the top of the zone. The last appearance of *Dinogymnium* sp. and *Ophiobolus lapidaris* marks the top of the zone.

The usefulness of the microfloral changes used in establishing the zones remains to be demonstrated. The simultaneous disappearance of some species and the first appearance of other species may represent diastems or environmental change.

No correlations can be drawn between the provisional zones and the studies of others in this region which are, as yet, unfinished. Also, correlation with established calcareous microfossil zones is not possible due to the leaching of microfossils from the Round Bay section.

Several species recovered in the present study, exhibit restricted stratigraphic ranges but are known to occur higher and/or lower in the geologic record in other areas, for example *Gonyaulacysta orthoceras* (Lower Cretaceous to Oligocene), *Spongodinium delitiense* (Senonian to Danian), *Fromea amphora* (Albian to Upper Cretaceous) and *Deflandrea diebelii* (Maestrichtian to Eocene). Thus, the accompanying range chart and proposed zones must be used with caution since many of the range restrictions are undoubtedly due to environmental rather than evolutionary phenomena.

Microfloral Characteristics of the Cretaceous-Tertiary Boundary

Although 19 dinoflagellate species occur in both Cretaceous and Paleocene sediments

of the Round Bay area, the change in the assemblage at the boundary is rather marked. Of the twelve species making their first appearance above the boundary, several have not been reported in pre-Paleocene studies elsewhere. Seven species are considered by the author as being possibly diagnostic of Paleocene sediments in Maryland. They are listed in Table I with the age of the oldest previously reported occurrence and the location. Excepting *Deflandrea pulchra* n. sp., the remaining species are cosmopolitan.

The relatively distinctive change in the dinoflagellate assemblages at the Cretaceous-Tertiary boundary in Maryland would seem to indicate an unconformable relationship; however, the extent of the hiatus is not clear. The 19 species crossing the boundary would tend to indicate a diastem of rather minor proportions; however, it should be noted that some of the species which range across the boundary: *Deflandrea magnifica, Svalbardella australina, Spiniferites ramosus ramosus, S. ramosus granosus, Hystrichosphaeridium tubiferum,* and *Areoligera* spp. have ranges covering a considerable time interval on either side of the boundary (Drugg and Stover, 1975; Millioud, Williams and Lentin, 1975), and therefore they are probably species with a wide range of environmental tolerance.

The author believes on the basis of the previously discussed species distributions that a paraconformity exists at the Cretaceous-Tertiary boundary in the Round Bay, Maryland area. The extent of the hiatus is indeterminate in the present study and additional fossil phytoplankton data are necessary before an accurate determination can be made.

Comparison of the Dinoflagellate Assemblage with Assemblages of other Areas

The dinoflagellate assemblage of the Monmouth Formation is comparable to that described by Zaitaeff and Cross (1966) for the Navarro Group of Texas. Species in common include *Dinogymnium westralium, Deflandrea cooksonii, D. pannucea, D. magnifica* and *Cordosphaeridium fibrospinosum.* Although Zaitzeff and Cross (1966) illustrated other species resembling many encountered in the present study, their taxonomic treatment was insufficient to allow a more complete assemblage comparison.

The report by Wilson (1971) illustrated many European species which were found in the present study including: *Gonyaulacysta wetzelii, Deflandrea diebelii, D. minor, Spongodinium delitiense, Cyclonephelium distinctum* and *Cyclapophysis monmouthensis* n. sp. (identified by Wilson as *?Cannosphaeropsis* sp.).

The strata studies by Zaitzeff and Cross (1966) and Wilson (1971) are Navarroan and Maestrichtian in age respectively, and the similarity of their assemblages to the one described herein for the Monmouth Formation tends to support the placement of the Monmouth Formation in the Maestrichtian by Stephenson *et al.* (1942).

Table I

Diagnostic Paleocene Species
Round Bay, Maryland

Species	Oldest Previously Reported Age	Location
Deflandrea dilwynensis	Paleocene	Australia
Wetzeliella cf. *W. pilata*	Paleocene	S. Dakota, USA
Trichodinium hirsutum	Paleocene	Australia
Lanternosphaeridium bipolare	Paleocene	Australia
Deflandrea cf. *D. pentaradiata*	Paleocene	Australia
Palaeoperidinium basilium	Paleocene	California, USA
Deflandrea pulchra n. sp.	Paleocene	Maryland, USA

The dinoflagellate assemblage of the Brightseat Formation is comparable in part to various Australian localities described by Cookson and Eisenack (1965b, 1967) with regard to *Deflandrea dilwynensis, Deflandrea* cf. *D. pentaradiata, Lanternosphaeridium bipolare,* and *Trichodinium hirsutum.* The assemblage is also similar, although to a lesser extent, to those reported by Drugg (1967) and Morgenroth (1968). Only the reports by Drugg (1967) and Morgenroth (1968) identified their sediments as being Danian. The studies from Australia reported the age as Paleocene. The Brightseat Formation is apparently equivalent to the Australian Paleocene (see Table I); however, the definitive stage assignment must await completion of the study by Whitney on the Brightseat type locality.

VI. CONCLUSIONS

The Monmouth and Brightseat formations contain a rich and diverse dinoflagellate assemblage. Thirty-five genera and 66 species, of which two genera and nine species are new, are described in this study. The stratigraphic distribution of the taxa is summarized in Figure 4. The content of the assemblage changes suddenly at the Cretaceous-Tertiary boundary with 13 species making their first appearance at or just above the boundary. Nineteen species cross the boundary and 35 species are restricted to the Cretaceous. The rather sudden change in the nature of the dinoflagellate assemblage at the boundary is interpreted by the author to indicate a paraconformable relationship between the Cretaceous and Paleocene strata. The term paraconformity is used since there is little field evidence (a few pebbles, some lignite, and evidence of boring) indicating any extensive period of erosion at the boundary.

Changes in the dinoflagellate assemblages within the Monmouth Formation, which form the basis for provisional zones, are discussed in detail in the section on Biostratigraphy and are summarized in Figure 4. The zones are provisional and will be tested by future work in this region.

The dinoflagellate assemblage described herein supports the placement of the Monmouth Formation in the Maestrichtian by Stephenson *et al.* (1942), and corroborates the Paleocene age for the Brightseat Formation (Bennett and Collins, 1952).

VII. NOMENCLATURE AND TAXONOMY

The descriptive nomenclature used herein is derived primarily from the works of Downie and Sarjeant (1966) and Sarjeant (1974). The measurements presented in the systematic section are designed to convey the most significant features of the species under consideration. Rather than measure the apical horn length, a feature which is somewhat interpretative in the sense of where one places the base of the apical horn, the apical pericoel length was determined. The apical pericoel is defined as the distance from the distal end of the apical horn to the anterior edge of the endoblast. The remaining measurements are self explanatory.

A generalized family breakdown is employed. A list of genera, species and familial affinities follows. They are arranged in the same order in which they appear in the section on Systematic Palynology.

VIII. ACKNOWLEDGMENTS

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IX. SYSTEMATIC PALYNOLOGY

Phylum PYRRHOPHYTA
Class DINOPHYCEAE Fritsch 1935
Order GYMNODINIALES
(Poche) Lindemann 1928
Family GYMNODINIACEAE
(Berg) Schutt 1896

Dinogymnium sp.
Dinogymnium westralium (Cookson and Eisenack 1958) Evitt *et al.* 1967

Order PERIDINIALES Schutt 1896
Family GONYAULACACEAE Lindemann 1928

Conosphaeridium cf. *C. striatoconus* (Deflandre and Cookson) Cookson and Eisenack 1969
Cordosphaeridium fibrospinosum Davey and Williams 1966b
Coronifera oceanica Cookson and Eisenack 1958
Cyclapophysis monmouthensis gen. et sp. nov.
Cyst Forma A
Cyst Forma B
Diphyes colligerum (Deflandre and Cookson) Cookson 1965
Diversispina truncata gen. et sp. nov.
Exochosphaeridium bifidum (Clarke and Verdier 1967) Clarke *et al.* 1968
Exochosphaeridium sp. complex
Gonyaulacysta orthoceras (Eisenack) Sarjeant 1966
Gonyaulacysta wetzelii (Lejeune-Carpentier) Sarjeant 1966
Hystrichokolpoma ferox (Deflandre) Davey 1969a
Hystrichokolpoma fimbriata Morgenroth 1968
Hystrichokolpoma unispinum Williams and Downie 1966a
Hystrichosphaeridium deanei Davey and Williams 1966b
Hystrichosphaeridium tubiferum (Ehrenberg) Davey and Williams 1966b
Lanternosphaeridium bipolare (Cookson and Eisenack) deConinck 1968
Lanternosphaeridium cf. *L. lanosum* Morgenroth 1966
Operculodinium centrocarpum (Deflandre and Cookson) Wall 1967
Spiniferites cf. *S. cornutus* (Gerlach) Davey and Williams 1966a
Spiniferites ramosus ramosus (Ehrenberg) Lentin and Williams 1973
Spiniferites ramosus granosus (Davey and Williams) Lentin and Williams 1973
Spongodinium delitiense (Ehrenberg) Deflandre 1936
Trichodinium hirsutum Cookson 1965b

Family PERIDINIACEAE
(Ehrenberg) Engler 1892

Deflandrea asymmetrica Wilson 1967
Deflandrea cooksonii Alberti 1959
Deflandrea dartmooria Cookson and Eisenack 1965a
Deflandrea diebelii Alberti 1959
Deflandrea cf. *D. diebelii* Alberti 1959
Deflandrea dilwynensis Cookson and Eisenack 1965b
Deflandrea echinoidea Cookson and Eisenack 1960
Deflandrea magnifica Stanley 1965
Deflandrea minor Alberti 1959
Deflandrea pannucea Stanley 1965
Deflandrea cf. *D. pentaradiata* Cookson and Eisenack 1965b
Deflandrea pulchra n. sp.
Deflandrea rhombohedra n. sp.
Deflandrea severnensis n. sp.
Deflandrea cf. *D. speciosa* Alberti 1959
Deflandrea cf. *D. striata* Drugg 1967
Deflandrea sp. A.
Palaeoperidinium basilium (Drugg) Drugg 1970
Palaeoperidinium cf. *P. deflandrei* (Deflandre) Lentin and Williams 1973
Spinidinium clavum Harland 1973
Svalbardella australina Cookson 1965b
Trithyrodinium striatum n. sp.
Trithyrodinium robustum n. sp.
Wetzeliella cf. *W. pilata* Stanley 1965

Family Uncertain

Aeroligera sp. (Lejeune-Carpentier) Williams and Downie 1966b
Cyclonephelium distinctum Deflandre and Cookson 1955
Cyclopsiella vieta(?) Drugg and Loeblich 1967
Diconodinium rhombiformis Vozzhennikova 1967
Fibradinium cf. *F. annetorpense* Morgenroth 1968
Fromea amphora Cookson and Eisenack 1958
Inversidinium caudatum n. sp.
Microdinium setosum Sarjeant 1966
Genus A
Genus B
Systematophora cf. *S. areolata* Klement 1960
Systematophora placacantha (Deflandre and Cookson) Davey *et al.* 1969
Tanyosphaeridium variecalamum Davey and Williams 1966b
Xenikoon australis Cookson and Eisenack 1960

Phylum PROTOZOA
Family OPHIOBOLIDAE Deflandre 1952

Ophiobolus lapidaris Wetzel 1933

Phylum PYRRHOPHYTA
Class DINOPHYCEAE Fritsch 1935
Order GYMNODINIALES (Poche)
Lindemann 1928
Family GYMNODINIACEAE (Berg)
Schutt 1898

Genus DINOGYMNIUM
Evitt *et al.* 1967

DINOGYMNIUM sp.

Plate 15, figures 1-3

Description: Fragile elongate cyst, dorsoventrally flattened, and tapering to a rounded point at both the apex and antapex. Cingulum observed only on lateral margins; separates short epitract from elongate hypotract. Hypotract to epitract length ratio 3-4.6:1. Sulcus weakly developed; extends onto epitract up to one third of epitract length. Cyst wall less than 1 micron thick, single layered, microreticulate. Archeopyle not observed.

Comments: This species of *Dinogymnium* is not formally named herein since it and related species are being extensively treated by F. May in a forthcoming publication. *Dinogymnium* sp. is commonly distorted because of its apparent fragility. Only three specimens were intact of which two were folded. The figured specimen is slightly folded anteriorly; however, it is the best preserved specimen. Although an archeopyle was not observed in the Round Bay specimens, Evitt *(in litt.)* reports that the archeopyle is on what is herein interpreted to be the posterior portion of the cyst in specimens from another locality (Texas). Re-examination of specimens from Round Bay, Maryland, and the Peedee Formation of North Carolina with both conventional light and scanning electron microscopy did not resolve the apparent discrepancy and at this time the author's interpretation of the cyst orientation remains unchanged.

Comparison with other species: Dinogymnium sp. does not appear similar to previously described fossil species in that it is flattened dorsoventrally, possesses indistinct sculpture and is extremely long. The high cingulum, sulcus on both epitract and hypotract, and the thin cyst wall would seem to indicate possible relationship with the modern form *Gymnodinium filum* (Lebour, 1917, plate 80, figure 6) and is a major factor in the maintainence of the author's original interpretation of the cyst orientation.

Dimensions: Three specimens measured; length 171-263 micra; width 20-28 micra; cyst wall thickness greater than 0.5 micron; less than 1 micron.

Occurrence: Very rare in samples 289, 291-293, Monmouth Formation.

DINOGYMNIUM WESTRALIUM
(Cookson and Eisenack)
Evitt, Clark and Verdier 1967
Plate 1, figures 1-3

1955 *Gymnodinium* cf. *G. heterocostatus* (Deflandre) DEFLANDRE and COOKSON, p. 248, plate 1, figure 7.

1958 *Gymnodinium westralium* COOKSON and EISENACK, p. 25, plate 1, figure 9.

1967 *Dinogymnium westralium* (Cookson & Eisenack) EVITT, CLARK and VERDIER, p. 23.

Comments: Only minor differences from the description of Cookson and Eisenack (1958) are seen on specimens of *Dinogymnium westralium* from the Monmouth samples. The fine punctations reported by Cookson and Eisenack (1958) are not clearly evident and a conspicuous sulcus, indeterminate in the original specimens, is present. An apical archeopyle is present. The epitract is slightly longer than the hypotract in some specimens. The cingulum is slightly levorotary and the sulcus is narrow. The longitudinal ridges possess an undulatory sculpture.

Dimensions: Six specimens measured; length 44-59 micra; width 26-35 micra.

Occurrence: Very rare in samples 280-285, 289, Monmouth Formation.

Previous Reported Occurrence: ?Upper Albian-Campanian, Australia (Cookson and Eisenack, 1960); Senonian, W. Siberia (Vozzhennikova, 1967); Maestrichtian, U.S.A. (Zaitzeff and Cross, 1968); Cretaceous, Australia (Cookson and Eisenack, 1970); Late Cretaceous, Australia (Deflandre and Cookson, 1955; Cookson and Eisenack, 1958).

Order PERIDINIALES Schutt 1896
Family GONYAULACACEAE
Lindemann 1928

Genus CONOSPHAERIDIUM
Cookson and Eisenack 1969

CONOSPHAERIDIUM cf.
C. STRIATOCONUS
(Deflandre and Cookson)
Cookson and Eisenack 1969
Plate 1, figures 4,5

Comments: A single, poorly preserved specimen resembling *Conosphaeridium striatoconus* was recovered. The ribs responsible for the striated appearance of the cones are not obvious in the specimen and it is slightly smaller than the range recorded for the original specimens. The cyst wall is bilayered, each layer less than 1 micron in thickness. The archeopyle is apical. The tabulation appears to be 6", 6c, 6‴, 1 p, 1⁗. The apical tabulation could not be determined because the operculum was missing.

Dimensions: One specimen measured; cyst main body diameter – 47 micra; process length 8-9 micra.

Occurrence: Single specimen in sample 293, Monmouth Formation.

Genus CORDOSPHAERIDIUM
Eisenack 1963 emend. Davey 1969c

CORDOSPHAERIDIUM FIBROSPINOSUM
Davey and Williams 1966b
Plate 1, figures 6, 7

1966b *Cordosphaeridium fibrospinosum* DAVEY and WILLIAMS, p. 86, plate 5, fig. 5.

Comments: Cordosphaeridium fibrospinosum encountered in this study resembles the original description with a few exceptions. The diameter of the central body ranges from 58-80 micra, slightly larger than the range of 59-70 micra given by Davey and Williams (1966b). The processes of the specimens recovered did not reach the maximum length of 39 micra of the topotypes and several examples exceeded the maximum process width of the topotypes. The wall is bilayered and its thickness in Monmouth-Brightseat specimens is up to 2 micra. The wall in the original description was cited as being 0.5 micron in thickness and bilayered. A precingular (Type P) archeopyle is always present.

Dimensions: Seven specimens measured; central body diameter 58-80 micra; process length up to 30 micra; process width up to 36 micra; wall thickness 2 micra; endophragm 0.5-1 micron; periphragm 1-1.5 micra.

Occurrence: Very rare in samples 280, 281, 284, 285, 287, 294, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: Maestrichtian, U.S.A. (Zaitzeff and Cross, 1968); Maestrichtian, Holland (Wilson, 1971); Eocene, England (Davey and Williams, 1966b); middle-upper Oligocene, Germany (Benedek, 1972).

Genus CORONIFERA
Cookson and Eisenack 1958

CORONIFERA OCEANICA
Cookson and Eisenack 1958
Plate 1, figure 8

1958 *Coronifera oceanica* COOKSON and EISENACK, p. 45, plate 12, figures 5, 6.
For detailed synonomy see Davey and Verdier (1971, p. 16).

Comments: Coronifera oceanica is rare and occurs only in a few samples. The numerous flexuous processes appear to be hollow at the base and are acuminate to finely capitate distally. Several processes on the epitract are fused proximally, up to 5.5 micra above the surface; the width of larger processes being about 4.5 micra. The tips of the larger processes are acuminate. An apical (Type A) or combination (Type A+P) archeopyle is frequently present.

Dimensions: Six specimens measured; central body 43-47 micra diameter; process length 15-17 micra; antapical process length 15-17.5 micra; width distally 12-13 micra; wall thickness 0.5 micron.

Occurrence: Very rare in samples 280, 282, 284, 291, 292, 295, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: upper Hauterivian-lower Aptian, France (Millioud, 1969); Aptian, Germany (Eisenack, 1958); Albian, Canada (Davey, 1969a); Albian, France (Davey and Verdier, 1971); Albian – basal Coniacian, England (Cookson and Hughes, 1964; Clarke and Verdier, 1967; Davey, 1969a); Albian, Cenomanian, Santonian-lowest Campanian, Australia (Cookson and Eisenack, 1958, 1968, 1969); upper Campanian, Canada (Harland, 1973).

CYCLAPOPHYSIS n. gen.

Derivation of name: cycl- (Gr) circle, *apophysis* (Gr) offshoot, process.

Type Species: Cyclapopyhsis monmouthensis.

Description: Chorate cyst with precingular (Type P) archeopyle. Cyst main body spheroidal to sub-oval. Distinct apical and antapical protuberance of cyst main body wall developed, surrounded by fibrous processes. Processes filamentous, plate centered. Precingular and postcingular processes bend toward cingulum with the tips fusing forming an equatorial tunnel continuous around cyst main body with indistinct interruption in sulcal region. Tabulation reflected by processes of 4', 0a, 6'', 0c, 6-7''', ?1p, 1''''.

CYCLAPOPHYSIS MONMOUTHENSIS
n. sp.

Plate 1, figures 9-12; Plate 2, figure 1

Derivation of name: Monmouth Formation, Maryland.

Holotype: Sample 291, slide AN 52, R 7.8, + 10.1.

Description: As for genus with the following additions: Apical protuberance generally longer than antapical, the ratio being as great as 3:1 and as small as 1.2:1. Cyst wall about 1 micron thick, its outer surface appearing microreticulate. Cyst wall bi-layered, the internal layer accounting for approximately 90% of its thickness. The outer microreticulate layer forms the process bases.

Dimensions:

Holotype: Cyst main body length 75 micra; width 65 micra. Apical: antapical protuberance ratio 2.4:1; processes in equatorial area 35 micra in length; total width in equatorial area 135 micra

Range: 17 specimens measured; cyst main body length 74-97 micra; width 58-71 micra. Apical: antapical ratio 3:1-1.2:1. Equatorial process length 24-40 micra. Equatorial width with processes 106-150 micra.

Comments: C. monmouthensis is distinctive in its equatorial distribution of fused precingular and postcingular processes. The cyst wall appears single layered; however, a thin periphragm is present. It is responsible for the microgranulate surficial texture, which upon close examination is seen to be the extensions of the filamentous process bases. The endophragm appears to be composed of fine fibers that are normal to the cyst surface.

Comparison with similar species: Cyclapophysis monmouthensis appears to be very similar to the specimen identified as *?Cannosphaeropsis* sp., that was illustrated by Wilson (1971, pl. 3, fig. 10). Both *C. monmouthensis* and *?Cannosphaeropsis* occur in sediments of highest Maestrichtian age. *C. monmouthensis* differs from *Cannosphaeropsis* in that the latter possesses sutural and gonal processes and distal trabeculae interconnecting all processes; whereas, in *C. monmouthensis* the processes are plate centered and the distal connections between processes are fused fibrils rather than trabeculae. *C. monmouthensis* is unique among the Pyrrhophyta. Cookson and Eisenack (1960) described *Codonia* (now *Codoniella* Downie and Sarjeant, 1964) *campanulata* which possesses trumpet-shaped processes only in the lateral portion of the equatorial region. The apical and atapical protuberances in conjunction with the precingular archeopyle are similar to those described for the genus *Lanternosphaeridium* (Morgenroth, 1966) and it seems possible that *C. monmouthensis* is related to that genus. In addition, the filamentous structure of the processes would appear to be additional support for a possible relationship of *C. monmouthensis* to *Lanternosphaeridium*, particularly *L. lanosum*.

Occurrence: Very rare to rare in samples 290-294, 296, Monmouth Formation and Brightseat Formation.

Cyst Forma A
Plate 2, figures 2-4

Comments: Two specimens were recovered. The cyst is spherical, bilayered and the periphragm is elevated into short, simulate processes. Some of the fields are open distally whereas others are closed. The archeopyle is an A + P type, although in the absence of more specimens the loss of the precingular plate equivalent may be coincidental. The reflected tabulation is ?, 6'', 6c, 6''', ?2s, 1p, 1''''. This pattern is the same as that of *Eisenackia* (McLean, 1973a); however, it differs from that genus is apparently possessing a combination (Type A + P) archeopyle. Additional specimens are necessary before the systematic position of this form can be understood.

Dimensions: Cyst main body diameter 40-42 micra; Periphragm plate equivalents up to 6 micra in height, 20 micra in width.

Occurrence: Two specimens in sample 281, Monmouth Formation.

Cyst Forma B
Plate 2, figures 10-12

Comments: A single specimen was recorded from the upper Monmouth Formation. The cyst is spheroidal, bilayered, and pos-

sesses an apical (Type A) archeopyle. The periphragm is elevated into fields reflecting plate equivalents. The free operculum was observed within the cyst. The tabulation observed is ?4', 6", 6c, 6"', 3s, 1p, 1"". Although the tabulation corresponds to that published by McLean (1973a) for the genus *Eisenackia,* the processes are hollow rather than the elevated pad-like plate equivalents discussed by McLean (1973a).

Dimensions: Cyst main body diameter 35 micra; periphragm plate equivalents up to 5 micra in height, 14 micra in width.

Occurrence: Single specimen in sample 292, Monmouth Formation.

Genus DIPHYES Cookson 1965a

DIPHYES COLLIGERUM (Deflandre & Cookson) Cookson 1965a
Plate 2, figure 5

1955 *Hystrichosphaeridium colligerum* DEFLANDRE and COOKSON, p. 278, plate 7, figure 3.
1963 *Baltisphaeridium colligerum* (Deflandre and Cookson) DOWNIE and SARJEANT, p. 91.
1965a *Diphyes colligerum* (Deflandre and Cookson) COOKSON, p. 86, plate 9, figures 1-12.
1966b *Diphyes colligerum* (Deflandre and Cookson) Cookson 1965a; DAVEY and WILLIAMS, p. 96, plate 14, figures 2, 3.

Comments: Diphyes colligerum is rare in the Round Bay section. The specimens generally conform to the original description. The archeopyle is apical (Type A) and the operculum is invariably missing. The cyst wall is bilayered, the endophragm being extremely thin (less than 0.5 micron), the periphragm being 1.5-2 micra. The processes are hollow, continuous with the periphragm, and closed distally by a finely capitate tip.

Dimensions: Five specimens measured; central body diameter 30-36 micra; process length 14-16 micra; antapical process length 16-19 micra; width (maximum) 10-14 micra.

Occurrence: Very rare to rare in samples 281, 283, 292, 293, Monmouth Formation; and 295, 297, Brightseat Formation.

Previous Reported Occurrence: Upper Cretaceous, Australia (Cookson, 1965a, 1967b); Danian, Argentina (Heisecke, 1970); lower Eocene, N. Germany, Belgium (Morgenroth, 1966); Eocene, Belgium (De-Coninck, 1968); lower Eocene, England (Davey and Williams, 1966b); lower Eocene, Australia (Deflandre and Cookson, 1955).

DIVERSISPINA n. gen.

Derivation of name: diversi- (L) various, *spina* (L) spine, in reference to the variety of processes on each individual cyst.

Type species: Diversispina truncata.

Description: Chorate cyst with plate centered hollow processes of varying sizes and morphology. Processes abruptly terminated and of aculeate, denticulate, and recurved-patulate types. Processes reflect tabultion of 4', 6", 6c, 5"', 1p, 1"", 4-5s. Archeopyle precingular (Type P). Cyst wall bilayered, periphragm giving rise to processes. Cingulum indicated by processes with flattened bases. Position of sulcus marked by small flexuous processes. Processes composed of fused hyaline fibrils.

DIVERSISPINA TRUNCATA n. sp.
Plate 2, figures 6-9

Derivation of name: truncata (L), in reference to the abrupt termination of the processes.

Holotype: Sample 285, slide AN 27, R 9.8 + 4.7.

Description: As for genus with the following additions: Cyst main body subspheroidal, cyst wall about 1 micron in thickness, the processes arising from the thin periphragm. Periphragm exhibits microreticulate sculpture. Apical plate equivalents distinguished by four small processes of varying distal termination. Antapical process is larger than others with complex termination.

Dimensions:

Holotype: Cyst main body length 58 micra; width 54 micra; process length 33-35 micra; width 5-12 micra.

Range: 12 specimens measured; cyst main body length 51-58 micra; width 44-54 micra; process length 23-35 micra; width 2-13 micra.

Comments: Diversispina truncata is distinctive in its possession of a variety of process types. The specimens usually occur in lateral view and in this orientation the archeopyle appears apical. The presence of the flattened cingular processes, distinctive

sulcal and antapical processes, however, facilitates the correct orientation and the precingular nature of the archeopyle is clear.

Comparison with similar species: Diversispina truncata resembles *Hystrichosphaeridium stellatum* Maier (1959), both forms bearing processes of varying size and morphology; however, the latter species has an apical archeopyle. In view of the fibrous nature of the processes (even though the fibrous character is obscure) *Diversispina truncata* is most likely related to the genus *Cordosphaeridium* (Davey, 1969a); however the lack of a fibrous periphragm in *D. truncata* and its varied process morphology would appear to be sufficient justification for making *Diversispina truncata* a separate taxon.

Occurrence: Very rare to rare in samples 282-286, 288, 290-294, Monmouth Formation and Brightseat Formation.

Genus EXOCHOSPHAERIDIUM
Davey *et al.* 1966

EXOCHOSPHAERIDIUM BIFIDUM
(Clarke & Verdier)
Clarke *et al.* 1968
Plate 3, figures 1, 2

1967 *Baltisphaeridium bifidum* CLARKE and VERDIER, p. 72, plate 17, figures 5-6, text figure 30.
1968 *Exochosphaeridium bifidum* (Clarke and Verdier) CLARKE, DAVEY, SARJEANT and VERDIER, p. 182.

Comments: The Monmouth specimens resemble those described by Clarke and Verdier (1967); however, there are several differences. The apical process in the Monmouth specimens is variably developed in both length and degree of branching and on some specimens is nearly indistinguishable from the normal process. The remaining processes are bifurcate distally and frequently bear fine accessory spines. The cyst is bilayered, with the periphragm being very fibrous and pitted. The archeopyle is precingular (Type P).

Dimensions: Ten specimens measured; main cyst body 50-61 micra; processes 16-20 micra; apical process up to 21 micra.

Occurrence: Very rare to rare in samples 279-284, 289, 290, Monmouth Formation.

Previous Reported Occurrence: Cenomanian-upper Campanian, England (Clarke and Verdier, 1967); Upper Cretaceous, S. Africa (Davey, 1969c).

EXOCHOSPHAERIDIUM sp. complex
Plate 3, figures 3-9

Comments: A complex population of variable chorate cysts with precingular archeopyles (Type P) was encountered in the lower samples of the Round Bay section. Individual specimens resemble *Exochosphaeridium phragmites* (Davey, Downie, Sarjeant, and Williams, 1966), *Amphorosphaeridium* sp. (Davey, 1969c) and *Trichodinium hirsutum* (Cookson, 1965b). Due to the intergradation observed, the variable degree of development of distinctive processes (apical, antapical, and cingular) and co-occurrence it was felt best to treat these forms as a variable population. The intergradation is the result of varying degrees of fusion of processes to form the apical, antapical and cingular processes. The mechanism causing this fusion is not understood; however, a distinct sequence appeared to exist. The fusion of processes to form distinct cingular processes was not observed in those specimens lacking an antapical process. Thus the developmental sequence would appear to be apical; to apical and antapical; to apical, antapical and cingular in terms of distinctive processes. The "end members" of the sequence are presented in Plate 3, figures 3, 4-6, 7-9, to allow the reader to visualize the sequence.

Dimensions: 20 specimens measured; cyst central body diameter 86-72 micra; process length up to 18 micra; apical process 16-21 micra; antapical process 18-22 micra; cingular process 15-18 micra.

Occurrence: Common to abundant in samples 279-282, Monmouth Formation.

Genus GONYAULACYSTA (Deflandre)
Sarjeant 1969

GONYAULACYSTA ORTHOCERAS
(Eisenack) Sarjeant 1966
Plate 3, figures 10, 11

1958 *Gonyaulax orthoceras* EISENACK, p. 388, plate 21, figures 3-14, plate 24, figure 1, text figure 29.
1966 *Gonyaulacysta orthoceras* (Eisenack) SARJEANT, p. 121, plate 114, figures 5, 6, text figure 29.
1969a *Cribroperidinium orthoceras* (Eisenack) DAVEY, p. 128.
1971 *Gonyaulacysta orthoceras* (Eisenack) Sarjeant; SINGH, p. 307.

Comments: *Gonyaulacysta orthoceras* conforms both in size and form to the type description by Eisenack (1958) with the exception of the plate boundaries, which are slightly wider than those of the original specimens. The author concurs with Singh (1971) who stated that the transfer to *Cribroperidinium* (Davey, 1969a) was unwarranted and apparently was the result of misinterpretation of the wide plate boundaries as additional plates. The tabulation of the Monmount specimens is 4', 6", 6c, 6"', 1p, 1"", archeopyle (Type P) precingular.

Dimensions: Ten specimens measured; length, 97-104 micra; width 82-86 micra.

Occurrence: Very rare to rare in samples 281-286, Monmouth Formation.

Previous Reported Occurrence: Valanginian-lower Aptian, Czechoslovakia (Vavrdova, 1964); Barremian, England (Sarjeant, 1966a); Barremian, U.S.S.R. (Vozzhennikova, 1967); Barriasian-lower Aptian, Switzerland, France (Millious, 1967, 1969); upper Aptian, Turonian, Barremian, Cenomanian, Germany (Alberti, 1959); Aptian, Germany (Eisenack, 1958, 1959); Albian, France (Davey and Verdier, 1971); Lower Cretaceous, Canada (Singh, 1971); middle-upper Albian, Canada (Brideaux, 1971); Turonian, Cenomanian, Poland (Gorka, 1963); Cretaceous, Germany (Gocht, 1959); Paleocene, Antarctica (Wilson, 1967b); middle Oligocene, Germany (Gocht, 1969); middle-upper Oligocene, German (Benedek, 1972).

GONYAULACYSTA WETZELII
(Lejeune-Carpentier) Sarjeant 1969
Plate 3, figure 12; Plate 4, figure 1

1939 *Gonyaulax wetzelii* LEJEUNE-CARPENTIER, p. 525, text figures 1, 2.
1969 *Gonyaulacysta wetzelii* (Lejeune-Carpentier) SARJEANT, p. 11.

Comments: *G. wetzelii* resembles *G. orthoceras* and it is difficult to separate the two species. Their tabulation of 4', 6", 6c, 6"', 1p, 1"", is identical. Plate boundaries in both are relatively wide and are represented by delicate sutural folds. There appears, however, to be a consistent difference in the lateral margin of the sulcus between the two species, that of *G. wetzelii* being lobate in appearance. In addition there is a difference in both the size and shape of plate 1"', that of *G. wetzelii* being small and narrowly trapezoidal in shape; whereas, the 1"' of *G. orthoceras* is larger and triangular. A minor difference exists with regard to the apical horn, which in *G. orthoceras* is consistently pronounced, whereas that of *G. wetzelii* is reduced. Both have a precingular (Type P) archeopyle.

Dimensions: Ten specimens measured; length, 75-89 micra; width, 65-75 micra.

Occurrence: Rare to abundant in samples 289-294, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: Campanian-Maestrichtian, Belgium (Wilson, 1971); Maestrichtian, Denmark (Wilson, 1971); Upper Cretaceous, Baltic (Lejeune-Carpentier, 1939); Upper Cretaceous, Belgium (Lejeune-Carpentier, 1946); Danian, N. Europe (Morgenroth, 1968).

Genus HYSTRICHOKOLPOMA Klumpp 1953 emend. Williams and Downie 1966a

HYSTRICHOKOLPOMA FEROX
(Deflandre) Davey 1969a
Plate 4, figures 2, 3

1937 *Hystrichosphaeridium ferox* DEFLANDRE, p. 72, plate 14, figures 3, 4.
1966a *Hystrichokolpoma ferox* (Deflandre) WILLIAMS and DOWNIE, p. 181.
1967 *Baltisphaeridium ferox* (Deflandre) CLARKE and VERDIER, p. 73, plate 15, figure 4.
1969a *Hystrichokolpoma ferox* (Deflandre) DAVEY, p. 159, plate 9, figures 5-7.

Comments: A single specimen of *H. ferox* was recovered. It has an apical (Type A) archeopyle. The main cyst body is granular conforming with the description by Deflandre (1937). The size of the specimen also conforms to Deflandre's (1937) measurements.

Dimensions: Cyst main body diameter 46 micra, process length 16-17 micra.

Occurrence: Single specimen in sample 280, Monmouth Formation, probably reworked.

Previous Reported Occurrence: lower Hauterivian, Germany (Gocht, 1959); upper Aptian, Germany (Eisenack, 1959); Albian-Cenomanian, Australia (Cookson and Eisenack, 1962); Albian-Cenomanian, England (Cookson and Hughes, 1964); Lower Cretaceous, Germany (Eisenack, 1958); Lower Cretaceous, Canada (Singh, 1971); Turonian-Cenomanian, England (Davey, 1969a); Cenomanian, France (Davey, 1969a); Cenomanian-Santonian, England (Clarke and Verdier, 1967); Senonian, France (Deflandre and Courteville, 1939); Cretaceous, Australia (Cookson and Eisenack, 1968); Danian, Germany (Wetzel, 1952); Danian, Argentina (Heisecke, 1970); Eocene, Belgium (DeConinck, 1968).

HYSTRICHOKOLPOMA FIMBRIATA
Morgenroth 1968
Plate 4, figures 4-6

1968 *Hystrichokolpoma fimbriata* MORGENROTH, p. 547, plate 45, figures 7-8.

Comments: Two specimens assignable to *H. fimbriata* were recovered. Several other poorly preserved specimens were observed. The membrane connecting the adjacent acuminate processes is thin, delicate and frequently absent. The reflected tabulation appears to be ?', 6", ?c, 6"', 1p, 1"", the apical tabulation being indeterminate since the operculum is absent. An apical archeopyle (Type A) is present.

Dimensions: Two specimens measured; main cyst body diameter 37-38 micra; process height 17-19 micra.

Occurrence: Very rare in sample 293; possibly present in 294, Monmouth Formation and Brightseat Formation, probably reworked.

Previous Reported Occurrence: Lower Cretaceous, Australia (Deflandre and Cookson, 1955); Cretaceous, Germany (Gocht, 1959); Danian, N. Europe (Morgenroth, 1968).

HYSTRICHOKOLPOMA UNISPINUM
Williams & Downie 1966a
Plate 4, figures 7-9

1966a *Hystrichokolpoma unispinum* WILLIAMS and DOWNIE, p. 179, plate 17, figures 6, 7.

Comments: H. unispinum compares closely with the original description. The tabulation is ?', 6", 6c, 5"', 1p, 1"". The number of sulcal processes appears to be four to five. The apical tabulation is indeterminate due to the loss of the apical operculum. An apical archeopyle (Type A) is present.

Dimensions: Two specimens measured; cyst body 40-44 micra; large processes, 26 micra; small processes, 19 micra (sulcal).

Occurrence: Restricted to sample 295, very rare, Brightseat Formation.

Previous Reported Occurrence: Eocene, England (Williams and Downie, 1966a); Eocene, Belgium (DeConinck, 1968).

Genus HYSTRICHOSPHAERIDIUM
Deflandre 1937
emend. Davey and Williams 1966b

HYSTRICHOSPHAERIDIUM DEANEI
Davey and Williams emend.
Davey and Verdier 1971
Plate 4, figures 10-12; Plate 5, figure 1

1966b *Hystrichosphaeridium deanei* DAVEY and WILLIAMS, p. 58, plate 6, figures 4, 8.
1971 *Hystrichosphaeridium deanei* Davey and Williams; DAVEY and VERDIER, p. 22.

Comments: Two specimens of *H. deanei* were recovered; they compare favorably with the original descriptions. The processes are, as noted in the original description, variable in both size and shape. The diameter of the central body (35-37 micra) is slightly smaller than the original material (41-54 micra). The archeopyle is apical (Type A).

Dimensions: Cyst body diameter 35-37 micra; process length 14-28 micra, 16-23 micra; process width 2-16 micra, 2-14 micra.

Occurrence: Single specimens in samples 294 and 295, Brightseat Formation, reworked.

Previous Reported Occurrence: Albian, France (Davey and Verdier, 1971); middle to upper Cenomanian, France (Davey, 1969a); middle Cenomanian-Turonian,

England (Davey and Williams, 1966b; Clarke and Verdier, 1967; Davey, 1969a).

HYSTRICHOSPHAERIDIUM TUBIFERUM (Ehrenberg) Davey and Williams 1966b
Plate 5, figure 2

1966b *Hystrichosphaeridium tubiferum* (Ehrenberg) DAVEY and WILLIAMS, p. 56, plate 6, figures 1, 2; plate 8, figure 5; plate 10, figure 2, text figure 13.
For detailed synonymy prior to 1966 see Davey and Williams (1966b).

Comments: Hystrichosphaeridium tubiferum occurs throughout the section studied in this investigation and is of little value in a biostratigraphic sense. The specimens encountered agree with the description given by Davey and Williams (1966b) and are well within the published size range.

Dimensions: Ten specimens measured; diameter of central body 35-47 micra; process length 18-26 micra.

Occurrence: Very rare to common in samples throughout the section studied with exceptions of samples 283 and 289, where it was absent.

Previous Reported Occurrence: Barremian-Senonian, Canada (Pocock, 1962); Aptian, Germany (Eisenack, 1958); Albian, France (Davey and Verdier, 1971); Turonian, Maestrichtian, Campanian, Poland (Gorka, 1963); Senonian, Germany (Ehrenberg, 1838, 1854; Wetzel, 1933); Maestrichtian, Belgium (Lejeune-Carpentier, 1940); Maestrichtian, Belgium (Conrad, 1941); Maestrichtian-Danian, U.S.A. (Drugg, 1967); Cretaceous, Australia (Cookson and Eisenack, 1970); Paleocene, U.S.A. (Stanley, 1965); Danian, N. Europe (Morgenroth, 1968); Danian, Argentina (Heisecke, 1970); Early Cenozoic, S.E. Australia, W. New Zealand (Haskell and Wilson, 1975); Tertiary, Antarctica (Wilson, 1967); lower Eocene, N. Germany, Belgium (Morgenroth, 1966); Eocene, Belgium (DeConinck, 1969); lower Oligocene, Germany (Gocht, 1952); middle-upper Oligocene, Germany (Benedek, 1972); middle Oligocene-middle Miocene, Germany (Gerlach, 1961).

Genus LANTERNOSPHAERIDIUM Morgenroth 1966

LANTERNOSPHAERIDIUM BIPOLARE (Cookson & Eisenack) DeConinck 1968
Plate 5, figures 3-6

1965b *Cordosphaeridium bipolare* COOKSON and EISENACK, p. 135, plate 16, figures 7, 8.
1968 *Lanternosphaeridium bipolare* (Cookson and Eisenack) DeCONINCK, p. 38, plate 11, figures 1-6, 15, 16.
1969b *Amphorosphaeridium bipolare* (Cookson and Eisenack) DAVEY, p. 35.
1972 *Lanternosphaeridium bipolare* (Cookson and Eisenack) DeConinck; BENEDEK, p. 34, plate 5, figure 6.
1973 *Lanternosphaeridium bipolare* (Cookson and Eisenack) DeConinck; LENTIN and WILLIAMS, p. 85.

Comments: The specimens of *Lanternosphaeridium bipolare* are morphologically variable. Only a few specimens were observed that are identical with the type specimens figured by Cookson and Eisenack (1965b). The majority of the specimens are much more fusiform, as in Cookson and Eisenack (1967, plate 39, figures 1-5), than the originally described specimens and the antapical protuberance of the main cyst body is very pronounced and is up to 17 micra in length. The processes are composed of fused fibrils, exhibit varying degrees of basal fusion, and may be acuminate, capitate or flared. An apical fibrous extension of the periblast is frequently present, virtually identical to those figured by Cookson and Eisenack (1967). Although the specimens of this species are morphologically variable it is felt by the author that they represent a normal, variable population.

Dimensions: Ten specimens measured; cyst main body length 93-112 micra; width 44-62 micra; process length 12-17 micra; endophragm thickness greater than 0.5 micron; periphragm thickness less than 1 micron.

Occurrence: Rare in samples 294-297, Brightseat Formation.

Previous Reported Occurrence: Paleocene, Australian (Cookson and Eisenack, 1965); Paleocene, Australia (Cookson and Eisenack, 1967); Eocene, Belgium (DeConinck, 1969); middle-upper Oligocene, Germany (Benedek, 1972).

LANTERNOSPHAERIDIUM cf.
L. LANOSUM Morgenroth 1966

Plate 5, figures 7-9

Comments: Specimens resembling *Lanternosphaeridium lanosum* (Morgenroth, 1966) occur in both the upper Monmouth Formation and the lower Brightseat Formation. The Cretaceous specimens do not exhibit the apical and antapical protuberances reported by Morgenroth, and their central body size, like the Paleocene specimens, is slightly larger than the originally described forms. The Cretaceous forms exhibit a higher degree of fusion of the filamentous processes than the Paleocene specimens. The organized grouping of the filamentous processes in the Paleocene forms suggests that tabulation is present but it could not be determined from the specimens encountered. The central body is bilayered with a smooth, thin (slightly less than 1 micron) endophragm and a fibrous periphragm which is about 1.5 micra thick. The periphragm serves as the base of filamentous processes. Archeopyle is precingular (Type P).

Dimensions: Ten specimens measured; central body length 65-82 micra; width 53-71 micra; process height 18-34 micra; endophragm thickness greater than 0.5 less than 1 micron; periphragm thickness about 1.5 micra.

Occurrence: Very rare to common in samples 286, 289-292, 294-297, Monmouth Formation and Brightseat Formation.

Genus OPERCULODINIUM Wall 1967

OPERCULODINIUM CENTROCARPUM
(Deflandre & Cookson) Wall 1967
Plate 5, figures 10-12

1955 *Hystrichosphaeridium centrocarpum* DEFLANDRE and COOKSON, p. 272, plate 8, figures 3, 4.
1961 *Baltisphaeridium centrocarpum* (Deflandre and Cookson) GERLACH, p. 192, plate 28, figure 9.
1967 *Operculodinium centrocarpum* (Deflandre and Cookson) WALL, p. 111, plate 16, figures 1, 2, 5.
See Wall (1967, p. 111) for detailed synonymy.

Comments: Operculodinium centrocarpum is generally similar to the specimens described by Wall (1967). Adjacent processes are proximally fused; however, there is no regular distribution of the fused processes. The archeopyle is precingular (Type P).

Dimensions: Ten specimens measured; cyst body diameter 35-47 micra; process length 9-16 micra.

Occurrence: Rare to common in samples 294-297, Brightseat Formation.

Previous Reported Occurrence: Upper Cretaceous, S. Africa (Davey, 1969b); lower Eocene, N. Germany, Belgium (Morgenroth, 1966); Eocene, Belgium (DeConinck, 1969); middle Oligocene – middle Miocene, Germany (Gerlach, 1961); middle Oligocene – upper Miocene, Germany (Maier, 1959); Miocene, Sea of Japan (Shimakura *et al.*, 1971); Recent, Caribbean Sea (Wall, 1967).

Genus SPINIFERITES
Mantell 1850 emend. Sarjeant 1970

SPINIFERITES cf. S. CORNUTUS
(Gerlach) Davey and Williams 1966a
Plate 6, figures 1-3

Comments: A few specimens resembling *Spiniferites cornutus* (Gerlach, 1961; Davey and Williams, 1966a) were encountered. The specimens possess a finely to coarsely granular periphragm and variable development of the apical process. A precingular archeopyle (Type P) is present.

Dimensions: Two specimens measured; cyst body length 44, 58 micra; width 40, 43 micra; apical process 16, 35 micra.

Occurrence: One each in samples 293 and 295, Monmouth Formation and Brightseat Formation.

SPINIFERITES RAMOSUS RAMOSUS
(Ehrenberg) Lentin and Williams 1973
Plate 6, figures 4, 5

1838 *Xanthidium ramosum* EHRENBERG, plate 1, figures 1, 2, 5.
1938 *Hystrichosphaera ramosa* (Ehrenberg) WETZEL, p. 144.
1966a *H. ramosa* var. *ramosa* (Ehrenberg) DAVEY and WILLIAMS, p. 33, plate 1, figures 1, 6; plate 3, figure 1, text figure 8.
1973 *Spiniferites ramosus ramosus* (Ehrenberg) LENTIN and WILLIAMS, p. 130.
For detailed synonymy see Davey and Williams (1966a).

Comments: Specimens of *S. ramosus ramosus* are variable in their morphology and appear to intergrade with forms that can be attributed to other subspecies, such as *S. ramosus membranaceus* and *S. ramosus multibrevis*. They frequently exhibit abnormal development of sutural ridges similar to those figured by Davey and Verdier (1971). The central body is generally round to ovoidal. The archeopyle is precingular (Type P). The processes are gonal in position; however, intergonal processes are present in a few instances. Davey and Williams (1966a) suggested that the various subspecies of *S. ramosus* were of biostratigraphic importance; however, this is not apparent in the present study.

Dimensions: Ten specimens measured; central body diameter 37-48 micra; process length 10-15 micra.

Occurrence: Very rare to common in all samples examined, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: Barremian-Eocene, England (Davey and Williams, 1966a); Oxfordian, England (Sarjeant, 1962); Albian, Canada (Brideaux, 1971); Cenomanian-Santonian, England (Clarke and Verdier, 1967); Turonian-Maestrichtian, Poland (Gorka, 1963); Mesozoic, Italy (Serpagli, 1964); Lower Cretaceous, Canada (Singh, 1971); upper Campanian, Canada (Harland, 1973); Maestrichtian, U.S.A. (Zaitzeff and Cross, 1968); Upper Cretaceous, lower Eocene-Miocene, Australia (Deflandre and Cookson, 1955); Upper Cretaceous, Canada (McIntyre, 1974); Danian, U.S.A. (Drugg, 1967); Danian, Argentina (Heisecke, 1970); Tertiary, Antarctica (Wilson, 1967); Early Cenozoic, S.E. Australia, W. New Zealand (Haskell and Wilson, 1975); lower Eocene, N. Germany, Belgium (Morgenroth, 1966); lower Oligocene, Germany (Gocht, 1952); middle Oligocene-upper Oligocene, Germany (Benedek, 1972); middle Oligocene-middle Miocene, Germany (Gerlach, 1961); Miocene, Japan (Shimakura *et al.*, 1971).

SPINIFERITES RAMOSUS GRANOSUS (Davey and Williams) Lentin and Williams 1973

Plate 6, figure 6

1966a *Hystrichosphaera ramosa* var. *granosa* DAVEY and WILLIAMS, p. 35, plate 4, figure 9.

1973 *Spiniferites ramosus granosus* (Davey and Williams) LENTIN and WILLIAMS, p. 130.

Comments: The specimens of *S. ramosus granosus* resemble those described by Davey and Williams (1964a). The surficial granulation of the central body is variable in coarseness. The archeopyle is precingular (Type P).

Dimensions: Ten specimens measured; central body diameter 35-48 micra; process length 11-17 micra.

Occurrence: Very rare to rare in samples 279, 280, 282-284, 286-297, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: middle-late Albian, Canada (Brideaux, 1971); upper Campanian, Canada (Harland, 1973); upper Maestrichtian-lower Danian, Denmark (Wilson, 1971); Danian, Argentina (Heisecke, 1970); Eocene, England (Davey and Williams, 1966a).

Genus SPONGODINIUM Deflandre 1936

SPONGODINIUM DELITIENSE (Ehrenberg) Deflandre 1936

Plate 6, figures 7-9

1838 *Peridinium delitiense* EHRENBERG, p. 110, plate 1, figures 1, 6.

1936 *Spongodinium delitiense* (Ehrenberg) DEFLANDRE, p. 170.

Comments: The specimens of *S. delitiense* are generally well preserved. The vesicular appearance of the periphragm is distinctive and the specimens fit the original description closely. The archeopyle is precingular (Type P).

Dimensions: Five specimens measured; periblast length 125-130 micra, width 101-111 micra; endoblast diameter 89 micra; apical pericoel 32-36 micra.

Occurrence: Very rare in samples 280-281, Monmouth Formation.

Previous Reported Occurrence: Upper Cretaceous, Germany (Ehrenberg, 1838, 1854); Upper Cretaceous, Germany (Wetzel, O., 1933); Upper Cretaceous, France (Deflandre, 1936); Upper Cretaceous, Germany (Wetzel, W., 1952); Upper Cretaceous, Canada (McIntyre, 1974); Maestrichtian, Holland (Wilson, 1971); Danian, N. Europe (Morgenroth, 1968).

Genus TRICHODINIUM
Eisenack and Cookson 1960
emend. Clarke and Verdier 1967

TRICHODINIUM HIRSUTUM
Cookson 1965b
Plate 6, figures 10, 11

1965b *Trichodinium hirsutum* COOKSON, p. 139, plate 25, figures 5-13.

Comments: The specimens of *T. hirsutum* observed in this study closely resemble the original description. They differ in that the cyst wall is thicker (4-4.5 micra as opposed to 2.5 micra), the lateral cingular process are more prominent and the apical process is equal to or slightly longer than the antapical. They are different from the specimens of the *Exochosphaeridium* sp. complex in the Monmouth Formation in the consistently strong development of the cingular processes. The archeopyle is precingular (Type P).

Dimensions: Ten specimens measured; cyst main body 82-93 micra; cyst process length 18-20 micra; cingular process 19-38 micra; wall thickness-endophragm: 1 micron periphragm; 2.5-3.5 micra.

Occurrence: Rare to common in samples 295-297, Brightseat Formation.

Previous Reported Occurrence: Paleocene, Australia (Cookson, 1965b).

Family PERIDINIACEAE
(Ehrenberg) Engler 1892
Genus DEFLANDREA Eisenack 1938

Type species: Deflandrea phosphoritica Eisenack 1938.

Comments: The genus contains over 100 species, many of them probably being environmental variants of previously named species. In 1967 Vozzhennikova transferred some members of the genus into newly erected genera. The author feels that some of these transfers were unwarranted. In this paper the genus *Deflandrea* is used to contain those species which are cavate cysts, possess two antapical horns (one of which may be highly reduced) and exhibit an intercalary archeopyle in both the endoblast and periblast. Those forms exhibiting three intercalary plates involved in archeopyle formation either in the endoblast, periblast, or both, are placed in the genus *Trithyrodinium*.

DEFLANDREA ASYMMETRICA
Wilson 1967
Plate 6, figure 12

1967 *Deflandrea asymmetrica* WILSON, p. 67, figures 17-21.

Comments: Deflandrea asymmetrica is common in the lower part of the Round Bay section and closely resembles the description by Wilson (1967). Many specimens are finely granulate on the periphragm due to numerous small randomly distributed coni less than 0.5 micron in height. The endoblast is laterally separated from the periblast by a pericoel ranging from 2-2.5 micra in width. The left antapical horn is strongly developed whereas the right antapical horn is reduced to absent. The archeopyle is intercalary (Type I/Ia) and is attached or hinged along its posterior margin.

Dimensions: Ten specimens measured; periblast length 59-82 micra; width 37-56 micra; endoblast length 32-47 micra; width 29-50 micra; apical pericoel 10-21 micra.

Occurrence: Very rare to common in samples 279-283, Monmouth Formation.

Previous Reported Occurrence: ?Maestrichtian, Denmark (Wilson, 1971); Tertiary, Antarctica (Wilson, 1967); Early Cenozoic, S.E. Australia, W. New Zealand (Haskell and Wilson, 1975).

DEFLANDREA COOKSONII Alberti 1959
Plate 7, figures 1, 2

1959 *Deflandrea cooksonii* ALBERTI, p. 97, plate 9, figures 1-6.

Comments: This species is variable with regard to both the development of the epithecal "shoulders" and ornamentation of the periblast. Specimens occur in which the epitheca is slightly tapered; whereas, others exhibit strong "shoulder" development. Other specimens are ornamented with granules, small spines at the cingulum or on the hypotheca, or unornamented. All specimens have an intercalary archeopyle (Type I) on the periblast; whereas, the endoblast archeopyle is not obvious although it is presumed to be intercalary. The author interprets these differences as representing environmental variation and herein considers them to be an intergradative complex. Many of the variants have been set aside into separate species by previous workers, such as *D. tripartita* and

D. granulifera, however, they are treated in this study as belonging to the species *D. cooksonii.* The author hopes in the future to obtain the type specimens of the problematic species herein considered to belong to one complex, so that a detailed analysis of this problem can be undertaken.

Dimensions: Twenty specimens measured; periblast length 76-108 micra; width 40-54 micra; endoblast length 35-53 micra; width 34-64 micra; apical pericoel 6-12 micra.

Occurrence: Very rare to common in samples 279-283, 285, 287, Monmouth Formation.

Previous Reported Occurrence: Cretaceous, Australia (Cookson and Eisenack, 1960); upper Senonian, Germany (Alberti, 1959); Upper Cretaceous, U.S.S.R. (Vozzhennikova, 1967); Maestrichtian, U.S.A. (Zaitzeff and Cross, 1968); Maestrichtian, Denmark (Wilson, 1971); Maestrichtian-Danian, U.S.A. (Drugg, 1967).

DEFLANDREA DARTMOORIA Cookson and Eisenack 1965a
Plate 8, figures 1-3

1965a *Deflandrea dartmooria* COOKSON and EISENACK, p. 132, plate 16, figures 1, 2, text figure 1.

Comments: The specimens of *Deflandrea dartmooria* resemble the original description quite closely. The tabulation as indicated by intratabular fields of coni is 4', 3a, 7'', 5c, 5''', 2''''. The tabulation of the sulcal plates is indeterminate in the specimens observed; however, Stover (1973) reported that seven sulcal plates are probably represented. The archeopyle is intercalary (Type I).

Dimensions: Ten specimens measured; periblast length 114-117 micra; width 62-91 micra; endoblast length 58-68 micra; width 56-70 micra; apical pericoel 35-46 micra.

Occurrence: Very rare to common in samples 280, 283-296, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: Paleocene, Australia (Cookson and Eisenack, 1967); early Eocene, Australia (Cookson and Eisenack, 1965a; Stover, 1973).

DEFLANDREA DIEBELII Alberti 1959
Plate 8, figures 4-6

1959 *Deflandrea diebelii* ALBERTI, p. 99, plate 9, figures 18-21.

1967 *Ceratiopsis diebelii* (Alberti) VOZZHENNIKOVA, p. 159.

Comments: The transfer of *Deflandrea diebelii* to the genus *Ceratiopsis* by Vozzhennikova (1967) is herein rejected. Although the apical and antapical horns are elongate as pointed out by Vozzhennikova (1967), the archeopyle is clearly anterior intercalary (Type I) in position and not "equatorially" located as mentioned in the generic description by Vozzhennikova (1967). The present author feels that the species in question has greater affinities with *Deflandrea* and treats it as such. *Deflandrea diebelii* is rare in the study area. It is very distinctive due to its elongate apical and antapical horns, the distinct longitudinal folds and its large size. The cingulum is equatorial, and the sulcus, although indistinct, has a concavo-convex flagellar scar on the left side.

Dimensions: Ten specimens measured; periblast length 211-261 micra; width 58-73 micra; endoblast length 58-73 micra; width 65-73 micra; apical pericoel 83-107 micra; antapical pericoel 52-72 micra; periphragm less than 0.5 micron; endophragm less than 1 greater than 0.5 micron.

Occurrence: Very rare to rare in samples 279-282, 285, Monmouth Formation.

Previous Reported Occurrence: Upper Cretaceous, Canada (McIntyre, 1974); upper Senonian, Germany (Alberti, 1959); Maestrichtian, Poland (Gorka, 1963); Maestrichtian, Denmark (Wilson, 1971); Paleocene, U.S.S.R. (Vozzhennikova, 1967).

DEFLANDREA cf. D. DIEBELII Alberti 1959
Plate 8, figures 7-9

Comments: A few specimens of *Deflandrea* are present which are similar to *D. diebelii;* however, their size is about half that of the typical *D. diebelii.* The periphragm is thin and longitudinally wrinkled, the endophragm is about twice as thick as the periphragm and is externally smooth. The apical and antapical horns are elongate as in *D.*

diebelii. The archeopyle is intercalary (Type I). This species is present in both Cretaceous and Paleocene strata and its local range overlaps that of *D. diebelii* and extends much higher (into the Paleocene) in the section. This form may be the same as the *Deflandrea* sp. cf. *D. diebelii* reported by Stover (1973) and may represent aberrant individuals of that species.

Dimensions: Five specimens measured; periblast length 117-147 micra; width 41-55 micra; endoblast length 57-67 micra; width 35-41 micra; apical pericoel 47-58 micra; antapical pericoel 41-47 micra; endoblast wall greater than 0.5 and less than 1 micron; periblast wall greater than 0.2 and less than 0.5 micron.

Occurrence: Very rare to rare in samples 286, 289, 292-295, Monmouth Formation and Brightseat Formation.

DEFLANDREA DILWYNENSIS
Cookson and Eisenack 1965b
Plate 7, figures 3-5

1965b *Deflandrea dilwynensis* COOKSON and EISENACK, p. 141, plate 18, figures 6-9.

Comments: Deflandrea dilwynensis resembles the original specimens closely. The archeopyle is intercalary (Type I). It is considered by the author to be an excellent Paleocene indicator.

Dimensions: Ten specimens measured; periblast length 53-62 micra; width 41-47 micra; endoblast length 35-50 micra; width 35-41 micra; apical pericoel 11-18 micra.

Occurrence: Rare in samples 294-297, Brightseat Formation.

Previous Reported Occurrence: Paleocene, Australia (Cookson and Eisenack, 1965b; Stover, 1973).

DEFLANDREA ECHINOIDEA
Cookson and Eisenack 1960
emend. Sverdlove and Habib 1974
Plate 7, figures 6, 7

1960 *Deflandrea echinoidea* COOKSON and EISENACK, p. 2, plate 1, figures 5-6.
1971 *Deflandrea limpida* SINGH, p. 359, plate 61, figures 1-12.
1974 *Deflandrea echinoidea* Cookson and Eisenack; SVERDLOVE and HABIB, p. 58, plate 1, figures 1-6.

Comments: The specimens resemble those described by Cookson and Eisenack (1960) and Sverdlove and Habib (1974). Many of the specimens were poorly preserved and the accessory sutures described by Sverdlove and Habib (1974) were not seen. The tabulation appears to be 4', 3a, 7'', ?c, 5''', 2''''. The archeopyle is intercalary.

Dimensions: Ten specimens measured; periblast length 59-74 micra; width 44-56 micra; endoblast length 37-56 micra; width 32-49 micra; apical pericoel 6-12 micra.

Occurrence: Rare to abundant in samples 294-297, Brightseat Formation.

Previous Reported Occurrence: Lower Cretaceous, Canada (Singh, 1971); middle-late Albian, Canada (Brideaux, 1971); Albian, Canada (Davey, 1970); Turonian-lower Senonian, England (Davey, 1970): Santonian, England (Clarke and Verdier, 1967); Cretaceous, Australia (Cookson and Eisenack, 1970); upper Campanian, Canada (Harland, 1973).

DEFLANDREA MAGNIFICA Stanley 1965
Plate 7, figures 8, 9

1965 *Deflandrea magnifica* STANLEY, p. 218, plate 20, figures 1-6.

Comments: Deflandrea magnifica recovered in this investigation conforms morphologically closely to the description given by Stanley (1965). The archeopyle is intercalary (Type I). It is more variable in size than the specimens described by Stanley (1965).

Dimensions: Ten specimens measured; overall length range 88-118 micra; overall width range 82-102 micra; apical horn length 4-9 micra.

Occurrence: Very rare to rare in samples 280, 286-297, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: Maestrichtian-Danian, U.S.A. (Drugg, 1967); Maestrichtian, U.S.A. (Zaitzeff and Cross, 1968); Paleocene, U.S.A. (Stanley, 1965); Eocene, Belgium (DeConinck, 1967).

DEFLANDREA MINOR Alberti 1959
Plate 7, figure 10

1959 *Deflandrea minor* ALBERTI, p. 98, plate 9, figures 9-11.

Comments: The specimens of *Deflandrea minor* generally resemble those described by Alberti and are poorly preserved. The antapical horns are greatly reduced in the Monmouth specimens.

Dimensions: Ten specimens measured; periblast length 47-49 micra; width 35-45 micra; endoblast length 35-40 micra; width 33-41 micra; apical pericoel 7 micra.

Occurrence: Rare in samples 286-292, Monmouth Formation.

Previous Reported Occurrence: Upper Cretaceous, Canada (McIntyre, 1974); upper Senonian, Germany (Alberti, 1959); Maestrichtian, Denmark (Wilson, 1971).

DEFLANDREA PANNUCEA Stanley 1965
Plate 7, figures 11, 12

1965 *Deflandrea pannucea* STANLEY, p. 220, plate 22, figures 1-4, 8-10.

Comments: Deflandrea pannucea specimens are similar to those described by Stanley (1965). Some show a distinct sulcus, a feature noted as usually indistinct in the original description. The endoblast is variable in its posterior development ranging from being slightly flattened to strongly protruding into the antapical horns of the periblast. The endoblast appears to be externally microreticulate. The cingulum of the Monmouth Formation specimens is equatorial to slightly levorotary; the archeopyle is intercalary (Type I).

Dimensions: Ten specimens measured; periblast length 79-88 micra; width 53-60 micra; endoblast length 37 micra, width 47 micra.

Occurrence: Very rare to rare in samples 282-291, Monmouth Formation.

Previous Reported Occurrence: Maestrichtian, U.S.A. (Zaitzeff and Cross, 1968); Paleocene, U.S.A. (Stanley, 1965).

DEFLANDREA cf. D. PENTARADIATA
Cookson and Eisenack 1965b
Plate 9, figures 1-3

Comments: Deflandrea cf. *D. pentaradiata* is variable in its morphology. The lateral projections at the cingulum are frequently poorly developed and the endoblast is pentagonal to rounded in morphology. The longitudinal striae reported by Cookson and Eisenack (1965b) and Stover (1973) are absent. The periphragm is finely granular and the endophragm finely to coarsely granular. Specimens are illustrated in plate 9, figures 1-3, to show the typical range of variation.

Dimensions: Eight specimens measured; periblast length 82-124 micra; width 70-91 micra; endoblast length 54-93 micra; width 57-80 micra; apical pericoel 9-26 micra.

Occurrence: Rare to common in samples 294-297, Brightseat Formation.

DEFLANDREA PULCHRA n. sp.
Plate 9, figures 4-9

Derivation of name: pulchra (L) beautiful.

Holotype: Sample 296, slide AN 69, R 3.7 + 6.2.

Description: Cavate cyst, peridinoid outline with intratabularly arranged coni on periblast. Periphragm and endophragm each about 0.5 micron in thickness. Reflected tabulation 4', 3a, 7'', ?c, 5''', 2''''. Apical horn with two short spines on antero-lateral margin, the spines directed anteriorly. Archeopyle intercalary (Type I/I) with posteriorly and occasionally laterally directed accessory sutures. Cingulum levorotary, offset up to 4 micra. Sulcus strongly developed, may extend up to 5 micra on epitract. Left antapical horn longer than right. Endoblast closely appressed to periblast, may protrude slightly into antapical horns.

Dimensions:

Holotype: Periblast length 69 micra; width 50 micra; endoblast length 46 micra; width 46 micra; apical pericoel 13 micra.

Range: 20 specimens measured; periblast length 56-74 micra; width 43-57 micra; endoblast length 40-54 micra; width 38-51 micra; apical pericoel 7-13 micra.

Comments: D. pulchra resembles *D. echinoidea* (Sverdlove and Habib, 1974); however, it differs in that the tabulation of *D. pulchra* is reflected by the intratabular rather than peritabular arrangement of the coni. Also it is Paleocene rather than Cretaceous in age.

Occurrence: Common to abundant in samples 295-297, Brightseat Formation.

DEFLANDREA RHOMBOHEDRA n. sp.
Plate 9, figures 10-12

Derivation of name: rhombus + hedra (Gr.), in reference to the shape of the cyst.

Holotype: Sample 294, slide AN 62, R 8.3 + 11.2.

Description: Cavate cyst with left antapical horn strongly developed giving a rhomboid periblast shape. Cyst bilayered, endophragm slightly less than 1 micron, periphragm very delicate and considerably less than 0.5 micron. Endoblast closely appressed to periblast with lateral pericoel being less than 1 micron. Endoblast protrudes into left antapical horn, position of right antapical horn frequently represented by a slight bulge or flattening on endoblast. Atabulate. Archeopyle intercalary (Type I/I). Cingulum weakly developed, slightly levorotary, slightly depressed sulcus faintly evident with concavo-convex flagellar scar just posterior to plane of cingulum. Endophragm smooth to microreticulate, periphragm smooth, may have faint wrinkles.

Dimensions:

Holotype: Periblast length 72 micra; width 35 micra; endoblast length 49 micra; width 33 micra; apical pericoel 9 micra.

Range: Eight specimens measured; periblast length 75-82 micra; width 33-40 micra; endoblast length 49-63 micra; width 30-37 micra; apical pericoel 9-19 micra.

Discussion: This species was previously described by McLean (1971) and is herein redescribed since the description was never validly published. McLean's (1971) name "rhombohedra" is retained since the forms are considered to be conspecific.

Comparison with other species: In its general appearance *D. rhombohedra* is somewhat similar to *D. asymmetrica* (Wilson, 1967); however, *D. rhombohedra* has a free operculum whereas *D. asymmetrica* possesses a posteriorly hinged operculum and frequently developes a right antapical horn. The elongate rhomboid shape with an endoblast of similar shape allows differentiation of *D. rhombohedra* from *D. acuminata* (Cookson and Eisenack, 1958) in that the endoblast of *D. acuminata* is circular and not closely appressed.

Occurrence: Very rare in samples 294, 295, 297, Brightseat Formation.

DEFLANDREA SEVERNENSIS n. sp.
Plate 10, figures 1-3

Derivation of name: Severn- for the Severn River in Maryland.

Holotype: Sample 288, slide AN 37, R 15.8 + 13.4.

Description: Cavate cyst with reduced apical and antapical horns. Periphragm and endophragm thin, each less than 0.9 micron in thickness. Periblast ornamented with varying numbers of short spines, frequently but not always intratabulary arranged reflecting a tabulation of 4', 3a, 7", ?c, ?5"", 2"". Tabulation generally incomplete on individual specimens. Archeopyle intercalary (Type I/I). Cingulum equatorial; slightly levorotary. Sulcus strongly developed. Endoblast closely appressed to periblast.

Dimensions:

Holotype: Periblast length 71 micra, width 65 micra; endoblast length 52 micra; width 61 micra; apical pericoel 9 micra.

Range: 15 specimens measured; periblast length 61-78 micra; width 56-65 micra; endoblast length 40-58 micra; width 51-61 micra; apical pericoel 6-13 micra.

Comments: Deflandrea severnensis is variable in the density of ornamentation, which frequently masks the tabulation. Tabulation was determined by examining many specimens. Because of the delicate walls, specimens are commonly distorted.

Comparison with similar species: Deflandrea severnensis resembles *D. ventriosa* (Alberti, 1959), differing from the latter in possessing tabulation as reflected by the spinose ornamentation. It also resembles *D. microgranulata* Stanley (1965); however, *D. severnensis* does not possess the fine granulations on the endoblast surface and tabulation is not evident on *D. microgranulata.* These three species are perhaps closely related and may reflect an evolutionary lineage or variation.

Occurrence: Very rare to abundant in samples 284-293, Monmouth Formation.

DEFLANDREA cf. D. SPECIOSA
Alberti 1959
Plate 10, figures 4-6

Comments: Several specimens of *Deflandrea* resemble *D. speciosa* (Alberti, 1959). They bear denticulated longitudinal ridges on the periblast; however, they differ from *D. speciosa* in that they are slightly smaller, the endoblast is more angular and the antapical horns do not diverge from the midline as much as in the original described and illustrated specimens. The archeopyle is intercalary (Type I).

Dimensions: Ten specimens measured; periblast length 82-105 micra; width 53-65 micra; endoblast length 48-52 micra; width 50-54 micra; apical pericoel 14-22 micra.

Occurrence: Very rare to rare in samples 287, 289-292, Monmouth Formation.

DEFLANDREA sp. A
Plate 10, figures 7-9

Description: Cavate cyst, peridinioid outline with intratabular coni. Periphragm and endophragm each about 0.6 micron thick. Reflected tabulation 4', 3a, 7'', ?c, 5''', 2''''. Archeopyle intercalary (Type I). Cingulum equatorial to levorotary with maximum offset of 3 micra. Endoblast closely appressed to periblast and protruding slightly into antapical horns. Lateral margins of epitract and hypotract slightly concave yielding an angular outline. Apical and antapical horns well developed.

Comments: Deflandrea sp. A. is unique in its appearance; however, insufficient specimens were recovered to establish the range of variation and thus to erect a new species. The intratabular coni vary from less than 1 micron to greater than 2 micra in height.

Dimensions: Five specimens measured; periblast length 74-88 micra; width 53-73 micra; endoblast length 43-53 micra; width 50-64 micra; apical pericoel 14-19 micra.

Occurrence: Very rare in samples 282-284, Monmouth Formation.

Genus PALAEOPERIDINIUM
Deflandre 1935 *ex* Sarjeant 1967

PALAEOPERIDINIUM BASILIUM
(Drugg) Drugg 1970
Plate 10, figures 10, 11

1967 *Peridinium basilium* DRUGG, p. 13, plate 1, figures 9-11.
1970 *Palaeoperidinium basilium* (Drugg) DRUGG, p. 810, plate 1, figure D.

Comments: The specimens of *Palaeoperidinium basilium* resemble those of Drugg (1967, 1970). The tabulation is indistinct and archeopyle development is not clear. Drugg stated that the archeopyle is epitractal and that appears to be the case in the majority of specimens observed, in that many specimens are split at the cingulum. However, some specimens are encountered that suggest transapical excystment. This may have been, however, a function of poor preservation and/or damage to the cyst.

Dimensions: Ten specimens measured; periblast length 103-119 micra; width 91-106 micra.

Occurrence: Common in sample 297, Brightseat Formation.

Previous Reported Occurrence: Upper Cretaceous, Canada (McIntrye, 1974); lower Danian, U.S.A. (Drugg, 1967); Danian, U.S.A. (Drugg, 1970).

PALAEOPERIDINIUM cf. P. DEFLANDREI (Deflandre)
Lentin and Williams 1973
Plate 10, figure 12; Plate 11, figure 1

Comments: Several poorly preserved specimens of *Palaeoperidinium* were recovered. The "growth lines" delineating plate boundaries are only faintly visible; however, their distribution resembles that of *P. deflandrei*. The specimens recovered are larger than those of 70-80 micra in length described by Deflandre (1936). Archeopyle not observed.

Dimensions: Six specimens measured; length 95-120 micra; width 90-110 micra.

Occurrence: Rare in samples 279-282, 284, Monmouth Formation.

Genus SPINIDINIUM
Cookson and Eisenack 1962

SPINIDINIUM CLAVUM Harland 1973
Plate 11, figures 2, 3

1973 *Spinidinium clavum* HARLAND, p. 674, plate 84, figures 5, 6, 10, text figure 9.

Comments: The cingulum is slightly levorotary in some of the specimens recovered from the Monmouth Formation. The spines of the Monmouth specimens are between 1 and 1.5 micra in length and are rarely bifid distally. The branches of the bifid tip lie at about right angles to the main body of the process, yielding a T-shaped process. The archeopyle is intercalary (Type I).

Dimensions: Ten specimens measured; periblast length 44-59 micra; width 31-37 micra; endoblast length 32-28 micra; width 29-34 micra; apical pericoel 6-10 micra.

Occurrence: Very rare to common in samples 280, 281, 291-295, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: upper Campanian, Canada (Harland), 1973).

Genus SVALBARDELLA Manum 1960

SVALBARDELLA AUSTRALINA Cookson 1965b

Plate 15, figures 5, 6

1965b *Svalbardella australina* COOKSON, p. 140, plate 25, figures 1-4.

1972 *Svalbardella australina* Cookson; MALLOY, p. 63.

Comments: Svalbardella australina exhibits variation in both size and ornamentation. Most specimens possess a smooth periphragm; however, slight granulation is present in some specimens. The specimens observed in the Paleocene portion of the section exhibit a reduction in the length of the antapical horn; however, the accessory spike is well developed. The archeopyle is (Type I) intercalary.

Dimensions: Ten specimens measured; periblast length 158-215 micra; width 38-63 micra; endoblast length 79-117 micra; width 36-61 micra.

Occurrence: Very rare to common in all samples except 285 and 297, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: Upper Cretaceous, W. Africa (Malloy, 1972); Maestrichtian, Denmark, (Wilson, 1971); Paleocene, Australia (Cookson, 1965b).

Genus TRITHYRODINIUM Drugg 1967 emend. Davey 1969b

TRITHYRODINIUM STRIATUM n. sp.

Plate 11, figures 4-8

Derivation of name: striatum (L), in reference to the striated appearance of the endoblast.

Holotype: Sample 281, slide AN 9, R 18.3 + 7.6.

Description: Cavate cyst with very thin, delicate periblast, which is frequently missing. Apical horn short, antapical horns unequally developed. Tabulation absent. Archeopyle intercalary, type 3I/3I. Periphragm thin, less than 0.5 micron thick with no distinct sculpture, endophragm about 1 micron thick, longitudinally striate with clear indication of cingulum.

Dimensions:

Holotype: Periblast length 82 micra; width 73 micra; endoblast length 65 micra; width 62 micra; apical pericoel 8 micra.

Range: No additional intact specimens for periblast measurements; endoblast length 61-66 micra; width 59-63 micra (ten specimens).

Comments: Trithyrodinium striatum is most frequently seen as an isolated endoblast due to the delicate nature of the periphragm. One of the specimens illustrated (plate 11, fig. 7) demonstrates the unusual nature of the intercalary plate relationship in this species. Plates 1a and 3a are fused in the midline anterior to the anterior edge of plate 2a. J. Lentin *(in litt.)* feels that the pentagonal nature of the 2a plate and the relationship of the 1a and 3a plates warrants the erection of a new genus; however, Evitt *(in litt.)* states that he has observed this morphology as one end member of a range of variation. Since the specimens are derived from a single locality the total variation cannot be determined and the author feels that the erection of a new genus would be premature. A fuller discussion of the variation in *T. striatum* is the subject of a forthcoming paper.

Comparison with similar species: Trithynodinium striatum is similar to *T. fragile* (Davey 1969b) and *T. evittii* (Drugg, 1967f)

in general morphologic aspects and size. All three species possess a thin periphragm; however, the fine punctae reported by Drugg (1967) are absent on *T. striatum,* and the endoblast is single layered rather than bilayered as reported by Davey (1969b) for *T. fragile*.

Occurrence: Very rare to rare in samples 280, 281, Monmouth Formation.

TRITHYRODINIUM ROBUSTUM n. sp.
Plate 11, figures 9-12; Plate 12, figure 1

Derivation of name: robustum (L), in reference to its appearance.

Holotype: Sample 281, slide AN 9, R 15.9 + 6.4.

Description: Cavate cyst with pronounced apical horn, antapical horns, and large circular to elliptical endoblast. Left antapical horn twice as long as right. Tabulation reflected by intratabular coni: 4', 3a, 6-7'', ?c, 5''', 1p, 2''''. Archeopyle type 3I on endoblast, type I on periblast. Cingulum levorotary, slightly greater than 1 cingulum width. Sulcus restricted to hypotract, up to 15 micra in width. Endoblast microreticulate to microgranulate. Endophragm 1 micron in thickness, increasing to 2 micra at apical and antapical ends. Periphragm slightly less than 1 micron in thickness.

Dimensions:

Holotype: Periblast length 153 micra; width 78 micra; endoblast length 69 micra; width 71 micra; apical pericoel 43 micra.

Range: 20 specimens measured; periblast length 101-153 micra; width 53-82 micra;

PLATE 1

Page

Figures 1-3. *Dinogymnium westralium* 181
Sample 283, slide AN 17, R 5.6, + 9.6. L x W 50 x 35 micra. Fig. 1: dorsal view. Fig. 2: ventral (transparency) view showing distinct sulcus. Fig. 3: enlargement showing apical archeopyle and undulatory sculpture of longitudinal ribs.

Figures 4,5. *Conosphaeridium* cf. *C. striatoconus* 181
Sample 293, slide AN 57, R 9.1, + 9. Diameter 47 micra, processes up to 9 micra. Fig. 4: optical section. Fig. 5: surface detail showing microreticulate sculpture.

Figures 6,7. *Cordosphaeridium fibrospinosum* 182
Sample 281, slide AN 10, R 14.3, + 4.5. Cyst body L x W 80 x 70 micra, processes up to 28 micra. Fig. 6: dorsolateral view showing precingular archeopyle and fibrous periphragm. Fig. 7: optical section showing wide fibrous processes.

Figure 8. *Coronifera oceanica* 182
Sample 284, slide AN 23, R 12, + 7.8. Cyst L x W 49 x 42 micra, antapical process 14 micra, optical section showing antapical process, apical operculum still in place.

Figures 9-12. *Cyclapophysis monmouthensis* gen. et sp. nov. 183
Holotype, Sample 291, slide AN 52, R 7.7, + 10. Cyst body L x W 75 x 65 micra. Figs. 9-11: dorsal, optical section and ventral (transparency) views respectively. Note the distal interconnection of precingular and postcingular processes to form the equatorial "tunnel". Fig. 12: Periphragm and process detail.

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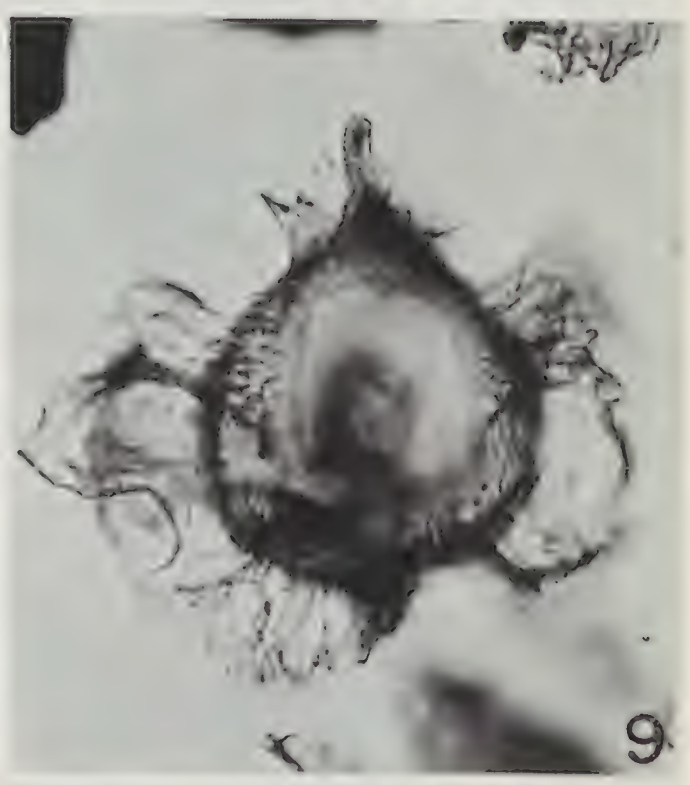
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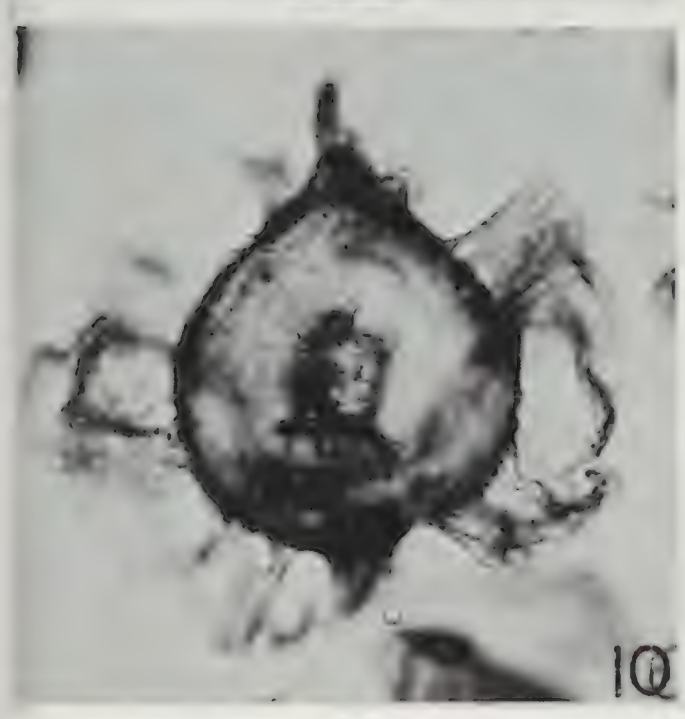
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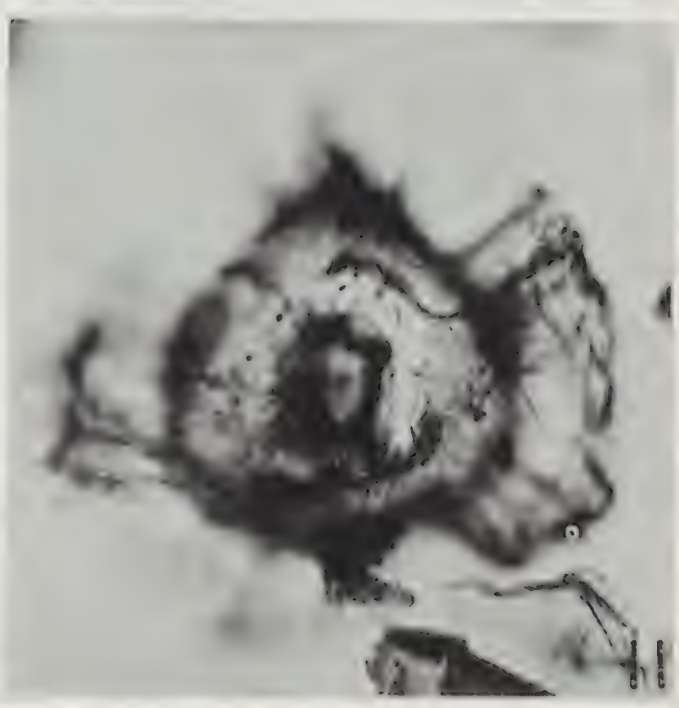
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PLATE 1

endoblast length 44-79 micra; width 46-75 micra; apical pericoel 29-47 micra.

Comments: Only rarely does a specimen exhibit complete tabulation because of the dense distribution of coni. The 3I archeopyle is observed with difficulty since the operculum is most frequently present. The thickening of the endoblast at its apical and antapical ends is apparently due to a localized increase in the height of the sculpturing and in those regions the endoblast appears to be bilayered and the outer layer may represent a mesophragm.

Comparison with similar species: The shape of *T. robustum* resembles the forms which Vozzhennikova (1967) placed in the genus *Australiella;* however, it lacks the strong development of epithecal "shoulders" as exhibited by the other members of that genus. Vozzhennikova's transfer included *Deflandrea tripartita* (Cookson and Eisenack, 1960), *D. thomasii* (Cookson and Eisenack, 1961), etc. All of these species possess a similar periblast shape, particularly with regard to the strong development of epithecal "shoulders." There is, however, a fundamental difference present within the above mentioned species. The archeopyle of *D. granulifera* and *D. thomasii* is type 3I with regard to the endoblast and type I with regard to the periblast (Manum and Cookson, 1964, plate 1, figures 5, 6, 8). *D. cooksonii* (Manum and Cookson, 1964, plate 1, figures 2, 3) and *D. tripartita* (Cookson and

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PLATE 2

Page

Figure 1. *Cyclapophysis monmouthensis* gen. et sp. nov. 183
Morphology of distal interconnections between precingular and postcingular processes.

Figures 2-4. Cyst Forma A 183
Sample 281, slide AN 9, R 12.3 + 12.6. Cyst body diameter 40 micra. Dorsal (transparency), optical section and ventral views respectively. Fig. 2: illustration of the combination archeopyle.

Figure 5. *Diphyes colligerum* 184
Sample 281, slide AN 9, R 15.2, + 5.5. Cyst diameter 33 micra, antapical process 12 micra. Optical section illustrating antapical process, bilayered wall, apical archeopyle and finely capitate processes.

Figures 6-9. *Diversispina truncata* gen. et sp. nov. 184
Holotype, Sample 285, slide AN 27, R 9.8, + 4.7. Cyst body L x W 58 x 54 micra, processes up to 35 micra. Figs: 6-8: Dorsal (transparency), optical section, and ventral views respectively. Note precingular archeopyle and flattened cingular process on Fig. 6, subtle fibrosity of process at 7 o'clock in Figs. 6,7, variable process termination and microreticulate sculpture on Fig. 8. Fig. 9: illustration of detail of process termination.

Figures 10-12. Cyst Forma B 183
Sample 292, slide AN 54, R 9.7, + 14.8. Cyst body diameter 35 micra. Figs. 10, 11: Dorsal and optical section views respectively. Note apical archeopyle and hollow processes. Fig. 12: Illustration of details of process base.

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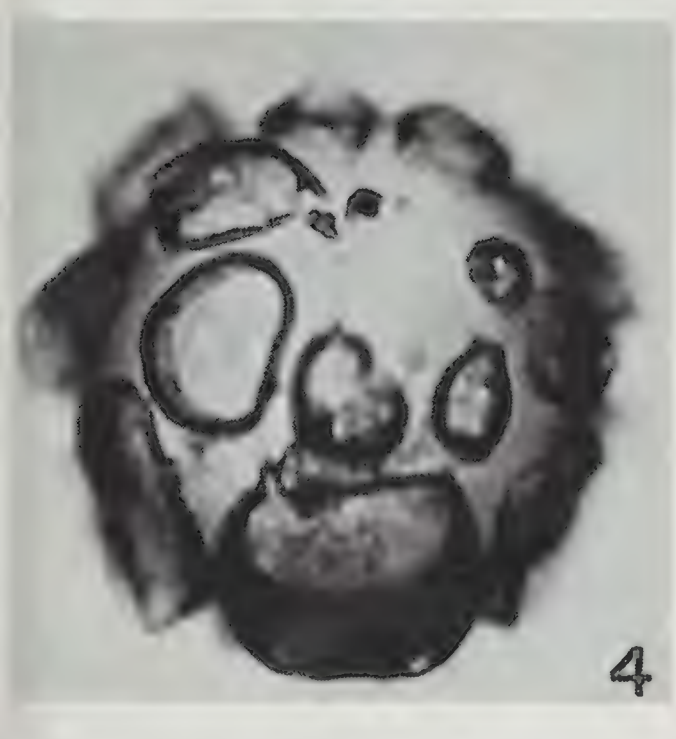
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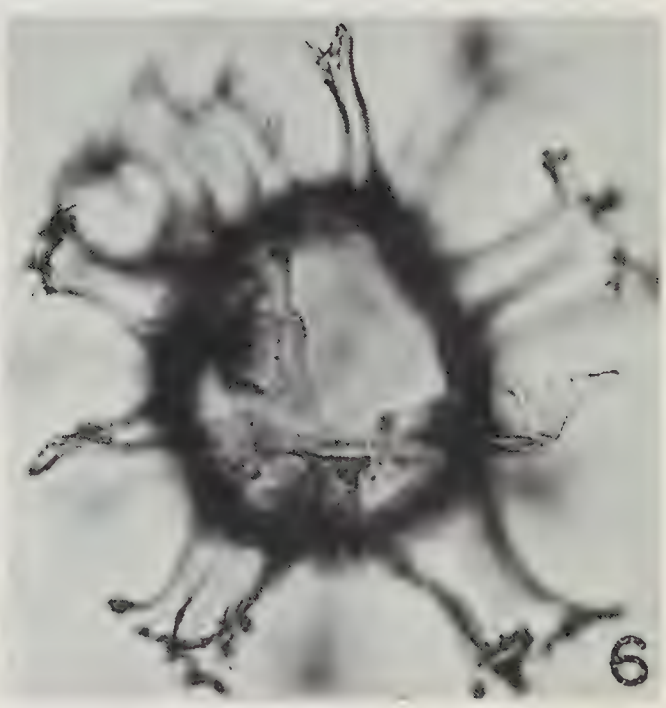
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PLATE 2

Eisenack, 1960, plate 1, figure 10), on the other hand, possess a type I archeopyle in both the endoblast and periblast. The transfer of species that have a similar periblast shape but different mode of archeopyle formation into the same genus appears to be questionable and will be dealt with in a separate publication.

It would appear that the affinities of *T. robustum* lie with those species of *Australiella* that exhibit a type 3I/I archeopyle. It differs from those species; however, in the weak development of epithecal "shoulders," and the presence of tabulation and larger antapical horns.

Occurrence: Rare to common in samples 279-281, Monmouth Formation.

Genus WETZELIELLA Eisenack 1938
emend. Williams and Downie 1966b

WETZELIELLA cf. W. PILATA
Stanley 1965

Plate 12, figures 2, 3

PLATE 3

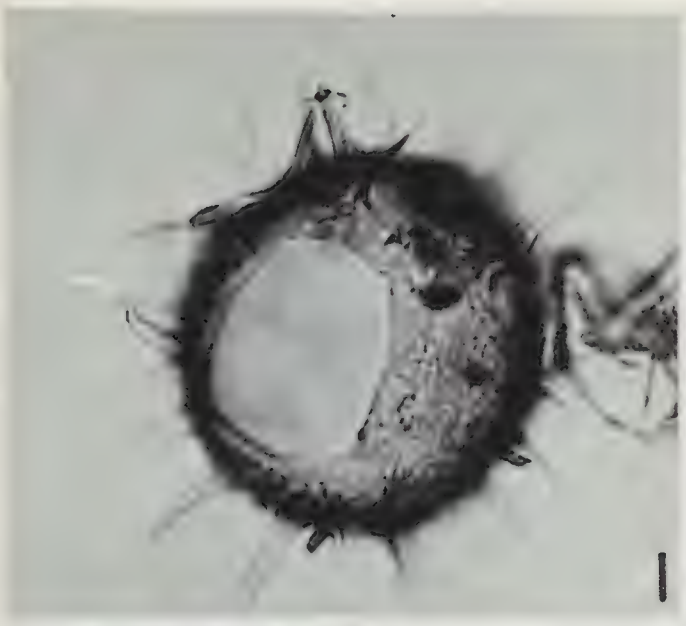
Page

Figures 1,2. *Exochosphaeridium bifidum* 185
Sample 285, slide AN 25, R 10.2, + 12.7. Cyst body diameter 58 micra, processes up to 13 micra, apical process 11 micra. Fig. 1: dorsal view showing precingular archeopyle, branched apical process and fibrous periphragm. Fig. 2: illustration of process termination, note spinelets on process at 2 o'clock.

Figures 3-9. *Exochosphaeridium* sp. complex 185
Fig. 3: Sample 281, slide AN 9, R 11.9, + 9.3, L x W 72 x 70 micra, apical process 14 micra, Figs. 4-6: Sample 281, slide AN 12, R 11.0, + 13.7. L x W 72 x 65 micra, apical process 14 micra, antapical process 16 micra. Figs. 7-9: Sample 281, slide AN 11, R 10.2, + 5.4. L x W 72 x 63 micra, apical process 14 micra, antapical process 21 micra, cingular process 16 micra. Fig. 3: dorsal view of specimen exhibiting apical process and precingulat archeopyle. Figs. 4-6: dorsolateral (transparency), optical section and ventrolateral views of specimen respectively, with apical and antapical processes. Note precingular operculum still in place, apical and antapical process visible in Figs. 5,6 respectively. Figs. 7-9: Dorsolateral (transparency), optical and ventrolateral views of specimen respecitvely, with apical antapical and cingular processes. Note tendency of cingular processes to be aligned in Fig. 7.

Figures 10,11. *Gonyaulacysta orthoceras* 185
Sample 285, slide AN 25, R 18.8, + 5.6. L x W 104 x 86 micra, Dorsal (transparency) and ventral views. Note apical horn and precingular archeopyle in Fig. 10. Ventral view illustrates surficial sculpture, plate boundaries and sulcal detail, compare with Plate 4, Fig. 1.

Figure 12. *Gonyaulacysta wetzelii* 186
Sample 289, slide AN 44, R 11, + 4.8. L x W 77 x 67 micra. Dorsal (transparency) view, note precingular operculum.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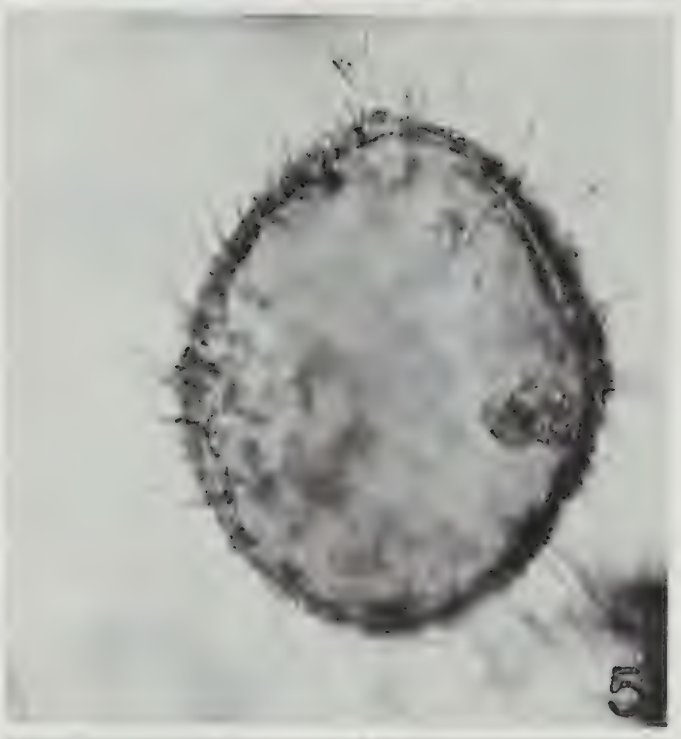
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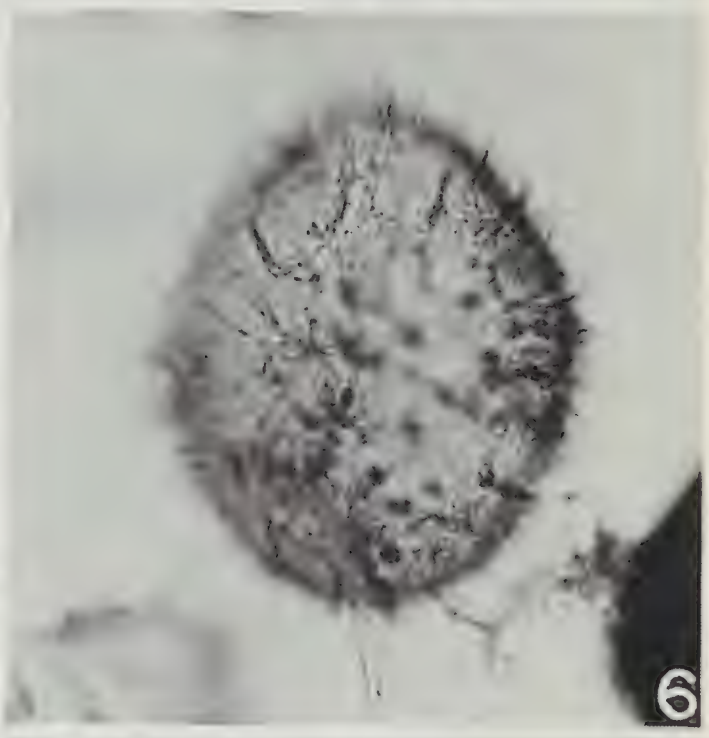
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PLATE 3

Comments: The specimens observed in this work resemble closely the original figures of Stanley (1965). They are slightly larger and the right antapical horn is more reduced than in Stanley's specimens. Although the distinctive capitate baculae are, or appear to be, primarily sutural in position the tabulation could not be determined with certainty. The epitract appears to be 4', 3a, 5-6'', (?)c. The hypotract could not be determined in the Monmouth specimens. The archeopyle is indistinct and appears to be intercalary (2a) in position. The periphragm and endophragm are thin, less than 0.5 micron and are separated by a pericoel about 2 micra in width.

Dimensions: Five specimens measured; periblast length 55-68 micra; width 42-51 micra; endoblast length 44-54 micra; width 38-47 micra; apical pericoel 7-9 micra.

Occurrence: Very rare in samples 295, 297, Brightseat Formation.

Family Uncertain
Genus AREOLIGERA
Lejeune-Carpentier 1938
emend. Williams and Downie 1966b

AREOLIGERA sp. (Lejeune-Carpentier)
Williams and Downie 1966b
Plate 12, figures 4-6

Comments: Several samples contained very large numbers of *Areoligera.* The population encountered is variable and intergradative forms with *Systematophora* sp. were observed. Due to the intergradation of forms

PLATE 4

Page

Figure 1. *Gonyaulacysta wetzelii* 186
Ventral view, same specimen as Plate 3, fig. 12. Compare sulcal details with Plate 3, fig. 11.

Figures 2, 3. *Hystrichokolpoma ferox* 186
Sample 280, slide AN 6, R 10.8, + 15.6. Cyst body diameter 47 micra, processes up to 17.5 micra. Fig. 2: Optical section showing apical archeopyle. Fig. 3: Enlargement illustrating process morphology.

Figures 4-6. *Hystrichokolpoma fimbriata* 187
Sample 293, slide AN 57, R 14.1, + 4.3. Cyst body diameter 38 micra, processes up to 19 micra. Figs. 4, 5: dorsal (transparency), and optical section views respectively. Fig. 6: Illustrates the morphological detail of the processes and periphragm.

Figures 7-9. *Hystrichokolpoma unispinum* 187
Sample 295, slide AN 67, R 11.7, + 7.2. Cyst body diameter 44 micra, large processes up to 26 micra in length, small processes up to 19 micra in length. Figs. 7, 8: Dorsal (transparency) and ventral views respectively. Fig. 9: View of ventral surface illustrating process bases and surficial detail.

Figures 10-12. *Hystrichosphaeridium deanei* 187
Sample 294, slide AN 64, R 17, + 13.2. Cyst body diameter 35 micra, processes up to 23 micra in length. Figs. 10-12: Dorsal, optical and ventral (transparency) views respectively. The process at 3 o'clock in Fig. 11 is illustrated in greater detail in Plate 5, fig. 1.

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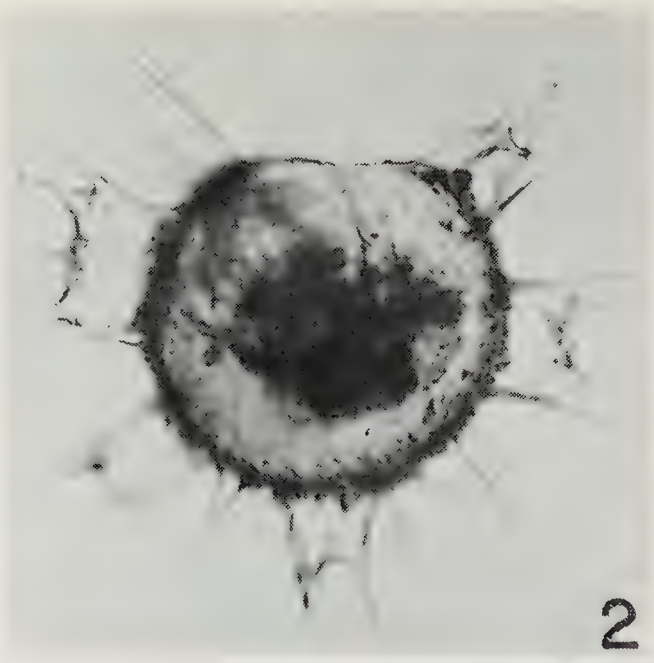
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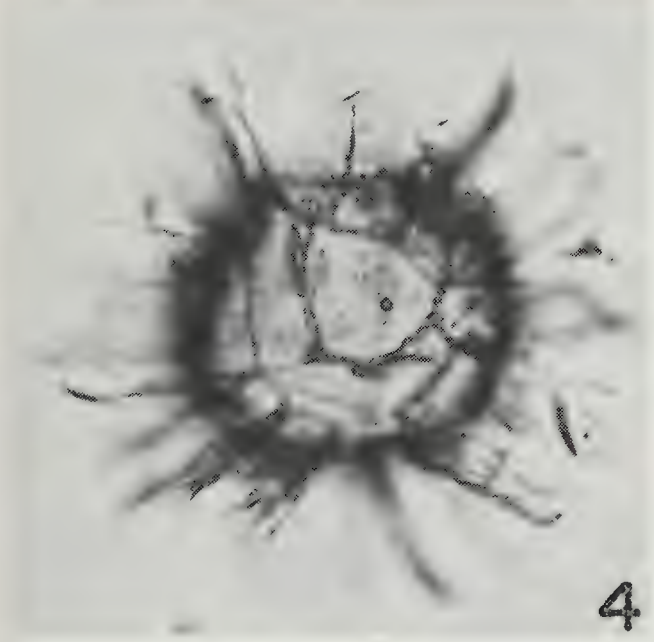
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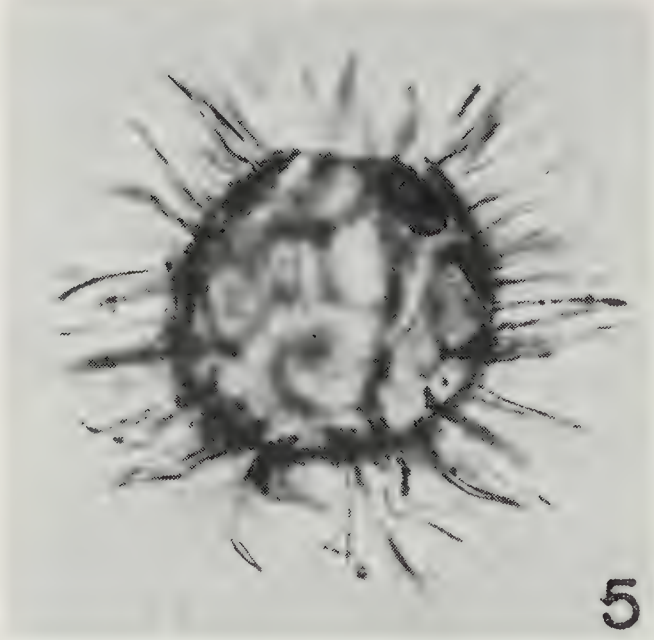
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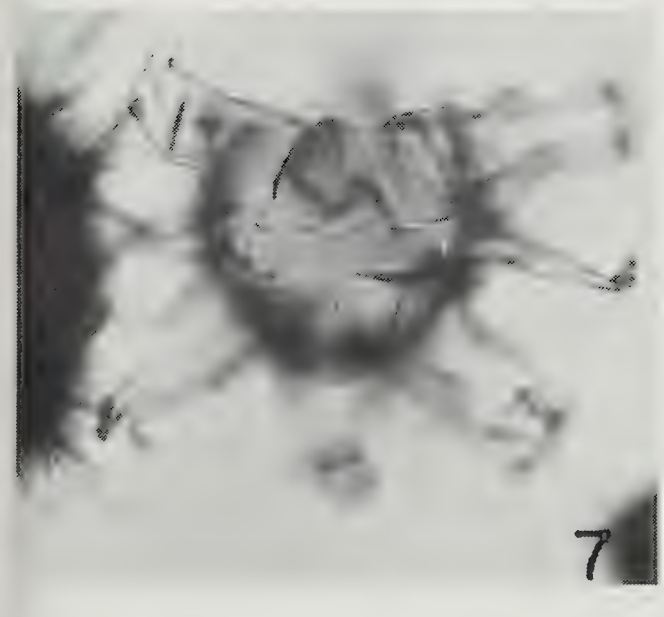
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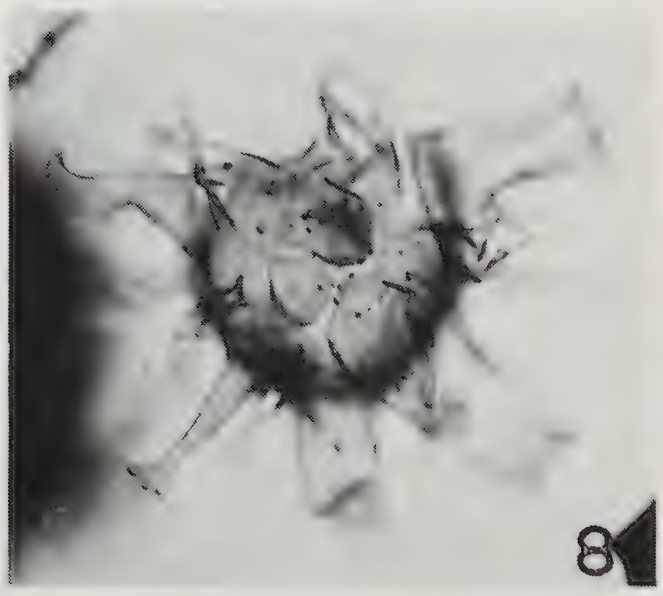
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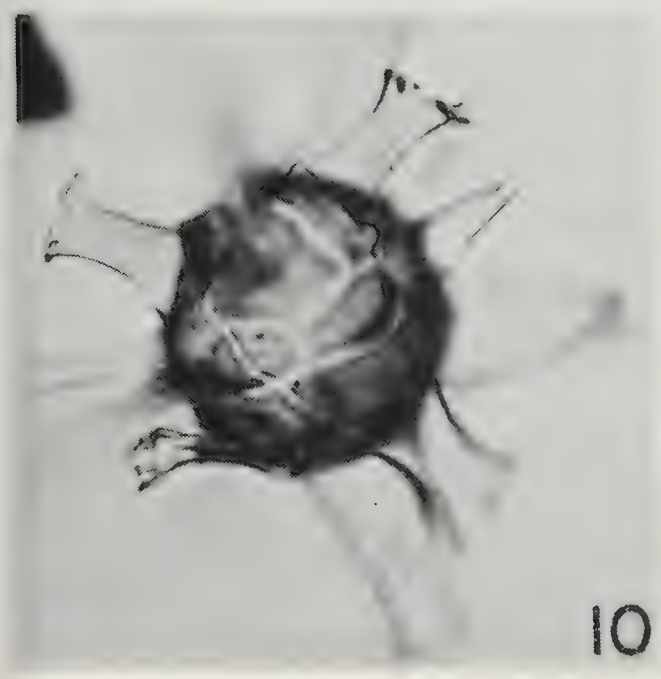
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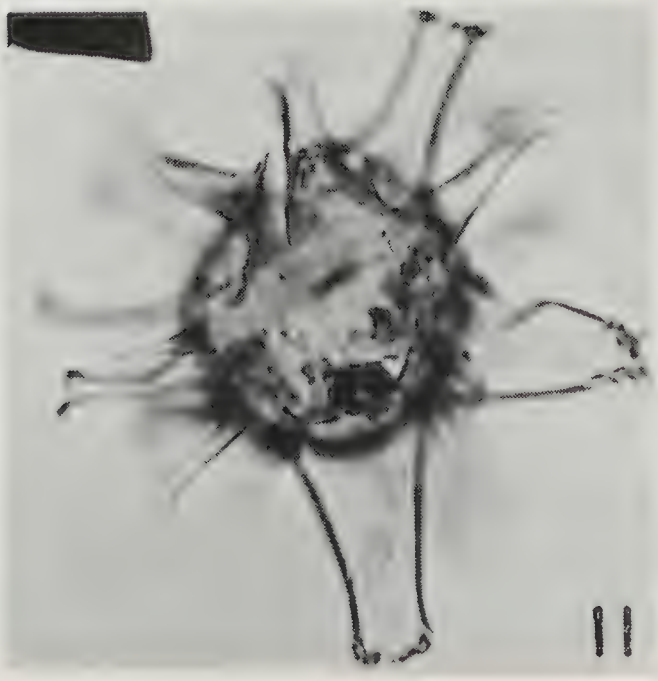
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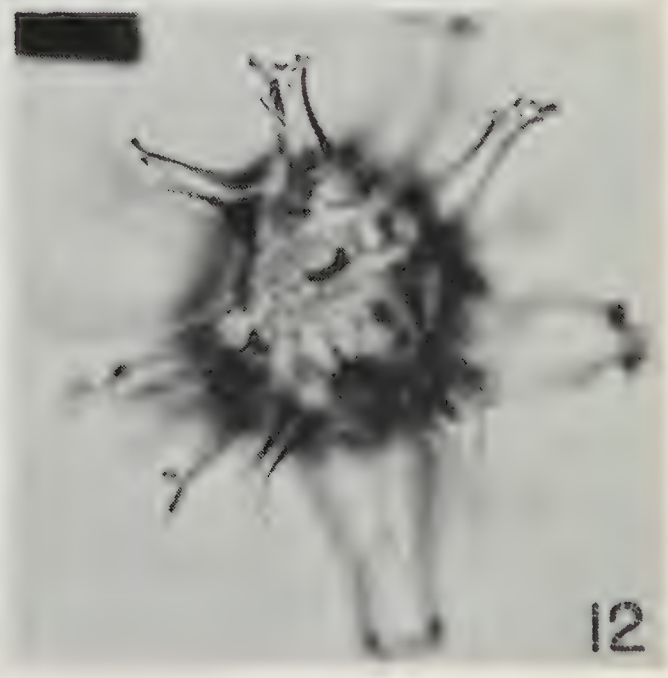
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PLATE 4

and the apparent lack of stratigraphic utility it was considered to be impractical to separate them at the specific level. For the purposes of this study, the cysts are combined as *Areoligera* sp. All specimens have an apical archeopyle (Type A).

Occurrence: Very rare to abundant in all samples, Monmouth Formation and Brightseat Formation.

Genus CYCLONEPHELIUM
Deflandre and Cookson 1955
emend. Williams and Downie 1966b

CYCLONEPHELIUM DISTINCTUM
Deflandre and Cookson 1955
Plate 12, figure 7

1955 *Cyclonephelium distinctum* DEFLANDRE and COOKSON, p. 285, plate 12, figure 14.

PLATE 5

Page

Figure 1. *Hystrichosphaeridium deanei* 187
Illustration of process at 3 o'clock in Fig. 11, Plate 4. Note accessory spinelets.

Figure 2. *Hystrichosphaeridium tubiferum* 188
Sample 297, slide AN 74, R 7.8, + 11.2. Central body diameter 47 micra, processes up to 35 micra long. Dorsal view showing apical archeopyle.

Figures 3-6. *Lanternosphaeridium bipolare* 188
A series of photomicrographs to illustrate the variation of the species in this study. Fig. 3: Sample 294, slide AN 63, R 7.5, + 10.6, L x W 73 x 47 micra. Fig. 4: Sample 295, slide AN 67, R 10.1, + 18.4, L x W 103 x 54 micra. Figs. 5, 6: Sample 295, slide AN 65 R 8.9, + 7.4, L x W 106 x 49 micra. Fig. 3: Dorsal view of specimen showing precingular archeopyle, antapical protuberance and abbreviated ramose apical process. This specimen is similar to the holotype figured by Cookson and Eisenack (1965). Fig. 4: Dorsolateral view of a specimen illustrating the apical elongation of the Brightseat specimens. Fig. 5: Lateral view of specimen with extreme apical elongation and fibrous extension of periblast identical to that illustrated by Cookson and Eisenack (1967). Fig. 6: Illustration of fibrous apical extension.

Figures 7-9. *Lanternosphaeridium* cf. *L. lanosum* 189
Sample 295, slide AN 67, R 6, + 12.4. Cyst L x W 71 x 61 micra, processes up to 23 micra long. Figs. 7, 8: Dorsal optical section views showing precingular archeopyle, fibrous periphragm, bilayered cyst wall. Fig. 9: View of dorsal surface illustrating surface and process detail.

Figures 10-12. *Operculodinium centrocarpum* 189
Sample 295, slide AN 67, R 11.4, + 11.2. Cyst L x W 44 x 40 micra, processes up to 10.5 micra long. Figs. 10, 11: Dorsal (transparency) and optical section views respectively. Note precingular archeopyle. Fig. 12: Illustrates details of process termination.

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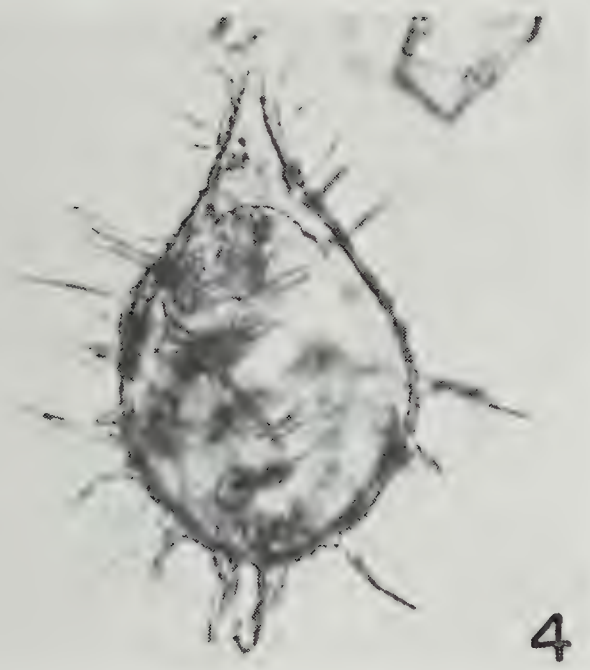
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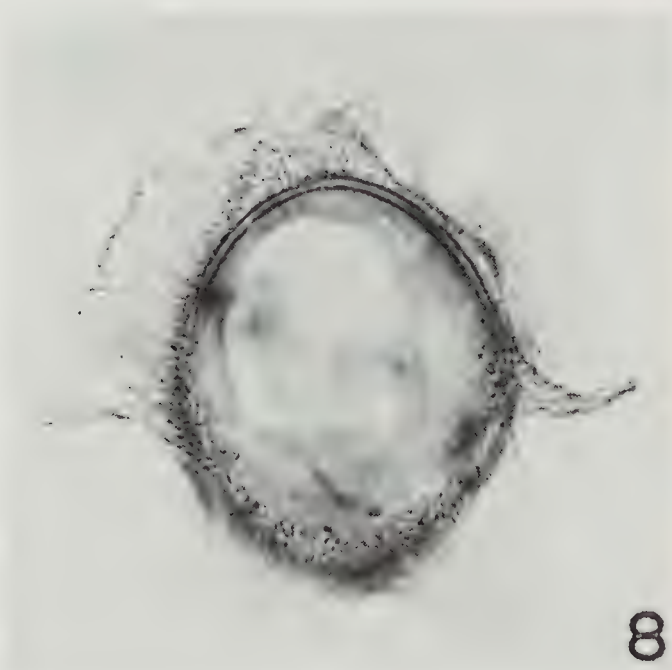
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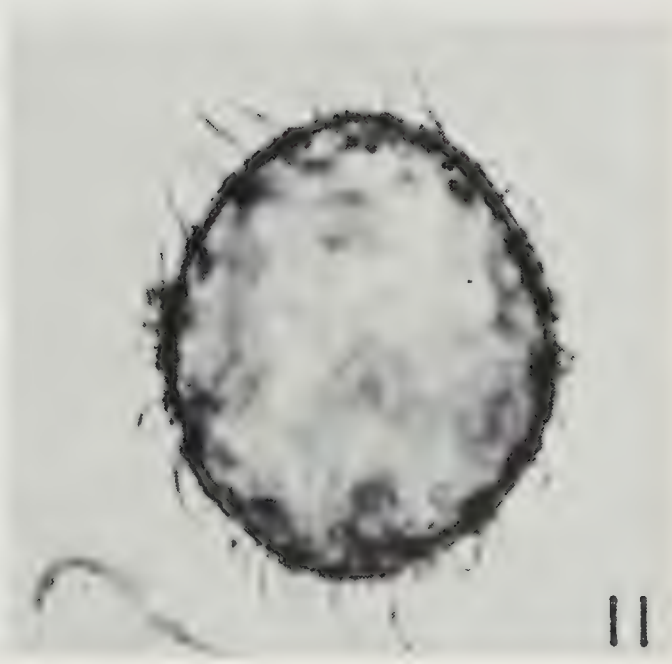
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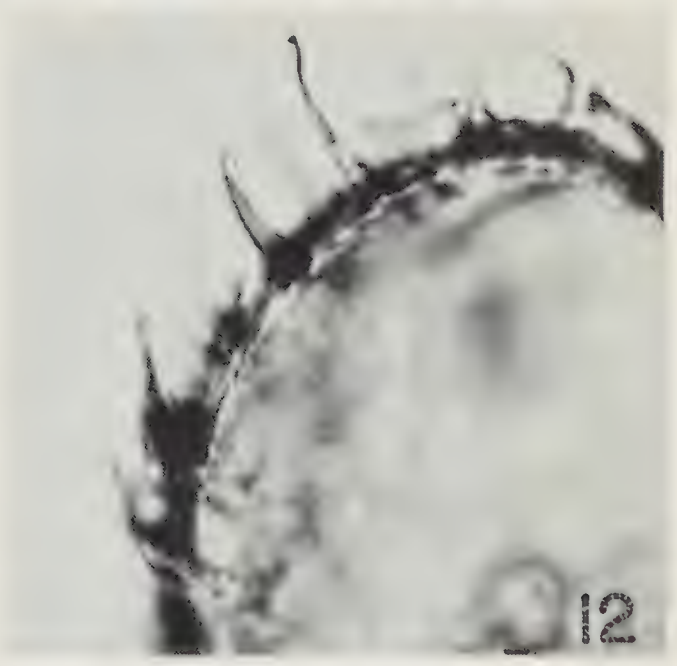
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PLATE 5

1961 *Circulodinium deflandrei* ALBERTI, p. 587, plate 6, figures 9-11.

1967 *Cyclonephelium distinctum* Deflandre and Cookson; CLARKE and VERDIER, p. 22, plate 1, figures 6, 7 — see also for earlier references.

Comments: Cyclonephelium distinctum possesses a variety of process types. The processes range up to 10 micra in length and vary from 0.5 micron to 3 micra in width. The wider processes are flared in form, their tips aculeate and appear to be composed of fine fibrils or filaments. The narrow processes are generally tapering to either an acuminate, capitate or digitate tip. The cyst wall is bilayered, about 1 micron in thickness, the periphragm giving rise to the processes and possessing a microreticulate sculpture. An apical archeopyle (Type A) is invariably present.

Dimensions: Ten specimens measured; cyst body diameter 39-58 micra; process length up to 10 micra in length; process width 0.5-3 micra.

Occurrence: Very rare to rare in samples 280, 281, 285-288, Monmouth Formation.

Previous Reported Occurrence: Lower Cretaceous, Canada (Singh, 1971); Berrias-

PLATE 6

Page

Figures 1-3. *Spiniferites* cf. *S. cornutus* 189
Sample 295, slide AN 67, R 14.6, + 1.8. Cyst L x W 58 x 43 micra, apical process 35 micra. Figs. 1, 2: Dorsal and optical section views respectively; Fig. 3: Illustration of dorsal surface showing coarse granules in cingular and post-cingular plate equivalents.

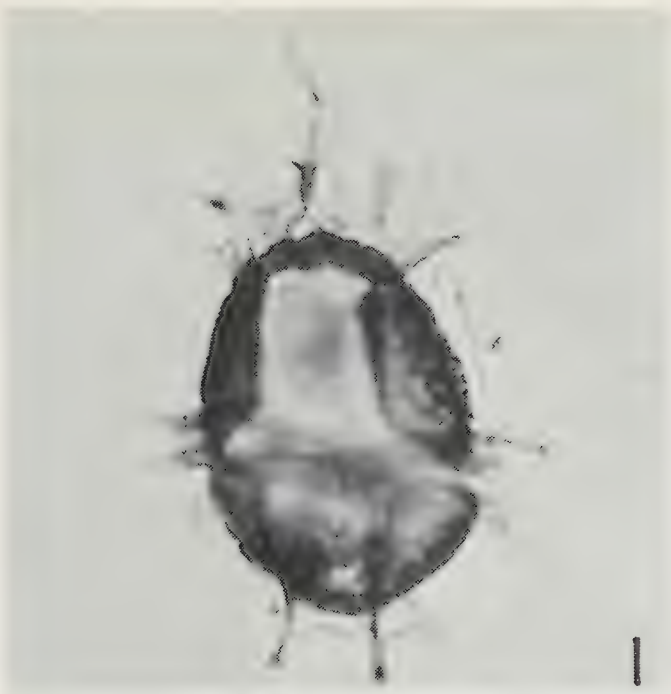
Figures 4, 5. *Spiniferites ramosus ramosus* 189
Sample 294, slide AN 61, R 14.6, + 12.2. Cyst L x W 44 x 40 micra, processes up to 16 micra long. Dorsal and ventral views (transparency) respectively.

Figure 6. *Spiniferites ramosus granosus* 190
Sample 295, slide AN 67, R 13.7, + 13.4. Cyst L x W 44 x 40 micra, processes up to 14 micra long. Dorsolateral view showing granular periphragm and gonal process placement.

Figures 7-9. *Spongodinium delitiense* 190
Sample 280, slide AN 5, R 13.4, + 9.1. Periblast L x W 129 x 112 micra, Endoblast diameter 89 micra. Dorsal (transparency), optical section and ventral views respectively. Note precingular archeopyle and vesicular periphragm. Note sulcal details in Fig. 9.

Figures 10, 11. *Trichodinium hirsutum* 191
Sample 296, slide AN 70, R 12.5, + 9.3. Cyst diameter 85 micra, apical process 35 micra, antapical process 32 micra, cingular process 23 micra. Dorsal (transparency) and optical section views respectively.

Figure 12. *Deflandrea asymmetrica* 191
Sample 279, slide AN 1, R 10, + 11.9. Periblast L x W 80 x 42 micra, Endoblast L x W, 46 x 37 micra. Dorsal view. The posteriorly hinged operculum is faintly visible on the epitract.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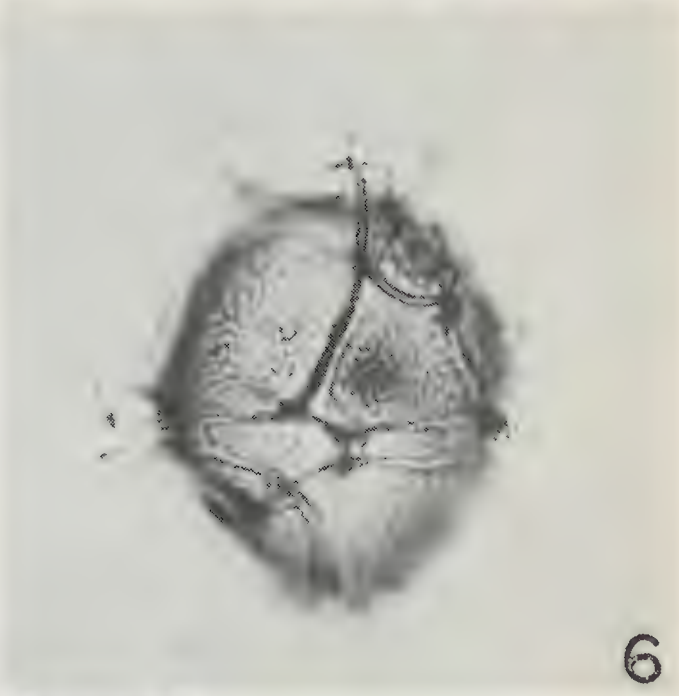
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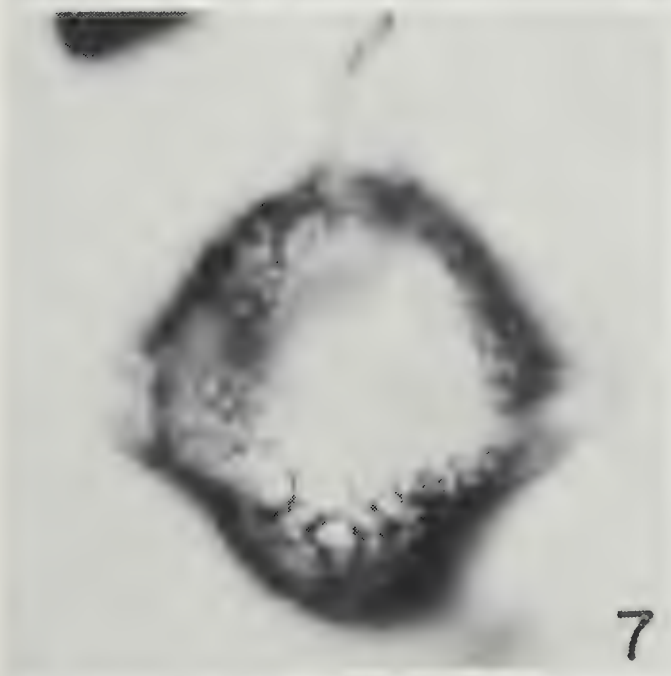
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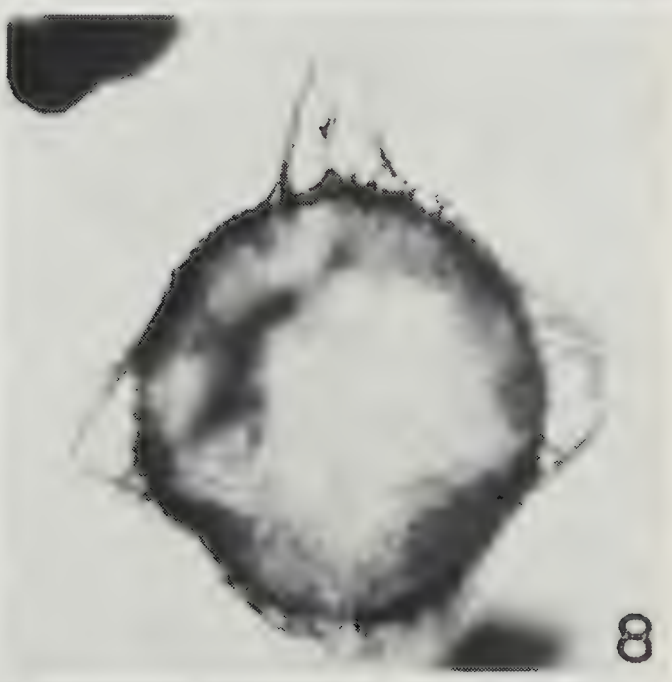
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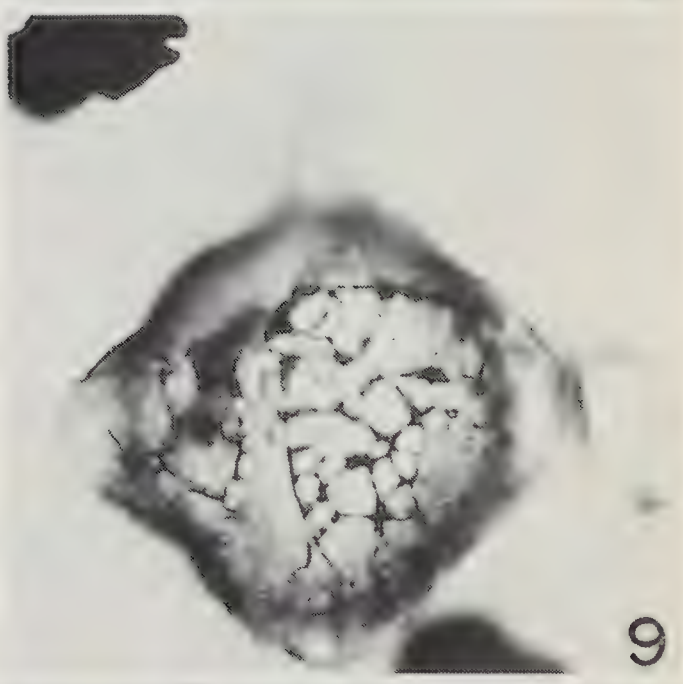
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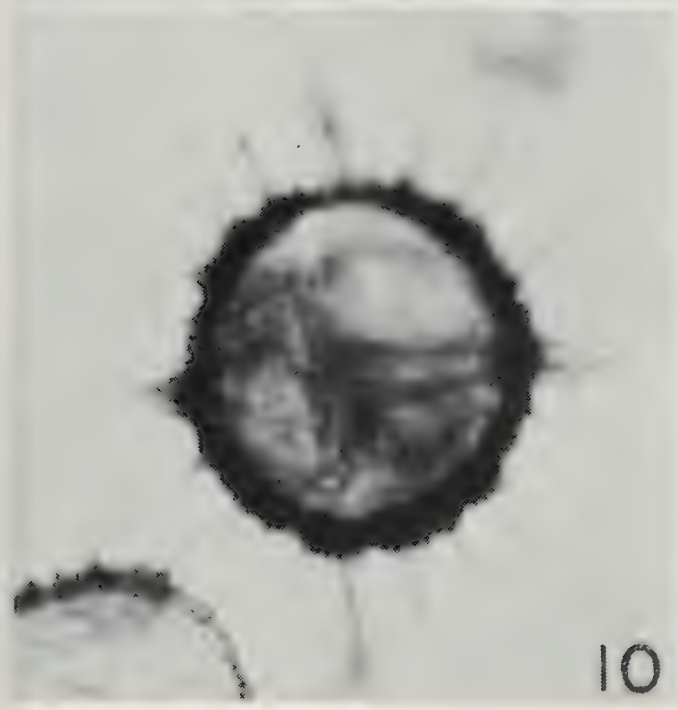
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PLATE 6

ian-lower Aptian, France, Switzerland (Millioud, 1967, 1969); Valanginian-Hauterivian, Germany (Gocht, 1959); Valanginian-lower Aptian, Czechoslovakia (Vavrdova, 1964); upper Hauterivian-Aptian (?), lower Albian, Germany (Alberti, 1961); Albian, Australia (Cookson and Eisenack, 1962); Albian, France (Davey and Verdier, 1971); Cenomanian, Canada, England, France (Davey, 1969a); Cenomanian-Senonian, England (Clarke and Verdier, 1967); Santonian-lower Campanian, Australia (Cookson and Eisen-

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PLATE 7

Page

Figure 1. *Deflandrea cooksonii* 191
Sample 281, slide AN 9, R 9, + 6.2. Periblast L x W 103 x 47 micra, endoblast L x W 41 x 45 micra. Dorsal view, an example of the specimens observed with poorly developed epithecal shoulders.

Figure 2. *Deflandrea cooksonii* 191
Sample 281, slide AN 9, R 9, + 6.1. Periblast L x W 100 x 50 micra, endoblast L x W 41 x 49 micra. Dorsal view, an example of the specimens observed with strong epithecal shoulder development.

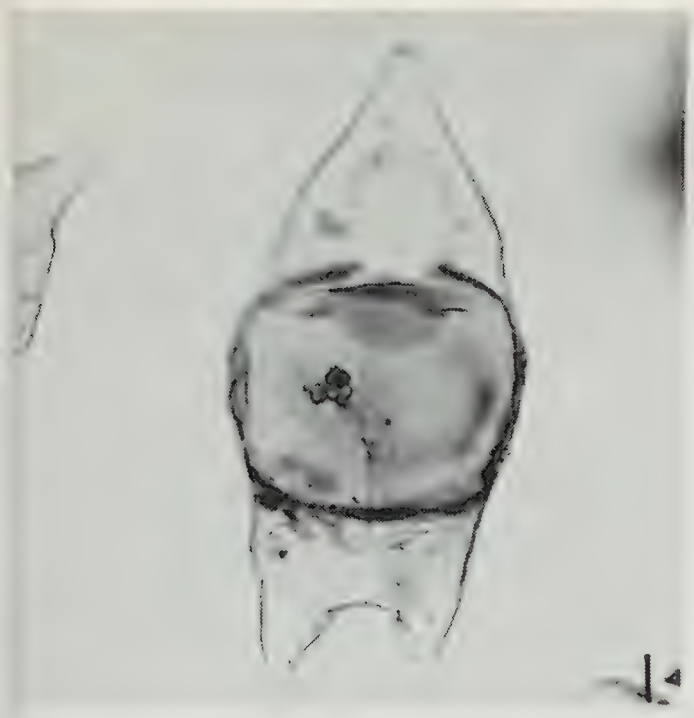
Figures 3-5. *Deflandrea dilwynensis* 193
Sample 294, slide AN 61, R 16.4, + 6.7. Periblast L x W 58 x 44 micra, endoblast L x W 35 x 40 micra. Dorsal (transparency), optical section, and ventral views, respectively. Note the archeopyle and longitudinal wrinkles in Fig. 3.

Figures 6, 7. *Deflandrea echinoidea* 193
Sample 294, slide AN 61, R 3.8, + 8.6. Periblast L x W 65 x 49 micra, endoblast L x W 47 x 40 micra. Optical section and ventral (transparency) views respectively.

Figures 8, 9. *Deflandrea magnifica* 193
Sample 291, slide AN 49, R 7.7, + 16.6. L x W 93 x 83 micra. Ventral and dorsal (transparency) views respectively. Note the longitudinal wrinkling and scattered fine granules. An intercalary archeopyle fine granules. An intercalary archeopyle is faintly visible on Fig. 9.

Figure 10. *Deflandrea minor* 193
Sample 287, slide AN 33, R 11.2, + 12.7. L x W 47 x 40 micra. Optical section. Note the weak development of the left antapical horn.

Figures 11, 12. *Deflandrea pannucea* 194
Sample 285, slide AN 25, R 15.7, + 9. Periblast L x W 85 x 53 micra, endoblast L x W 54 x 52 micra. Optical section ventral (transparency) views respectively. The outline of the archeopyle is evident in Fig. 11, as is the equal antapical horn development. Note the longitudinal wrinkles and widely scattered granules on Fig. 12.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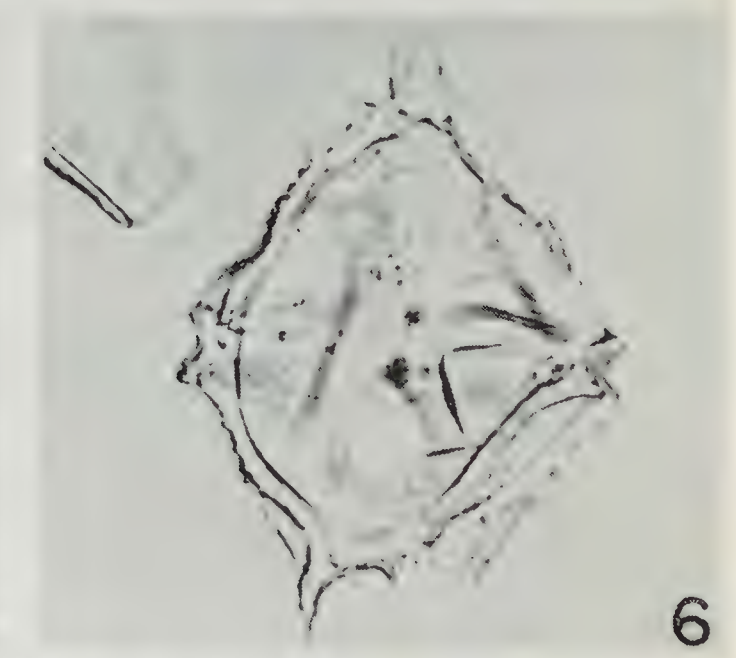
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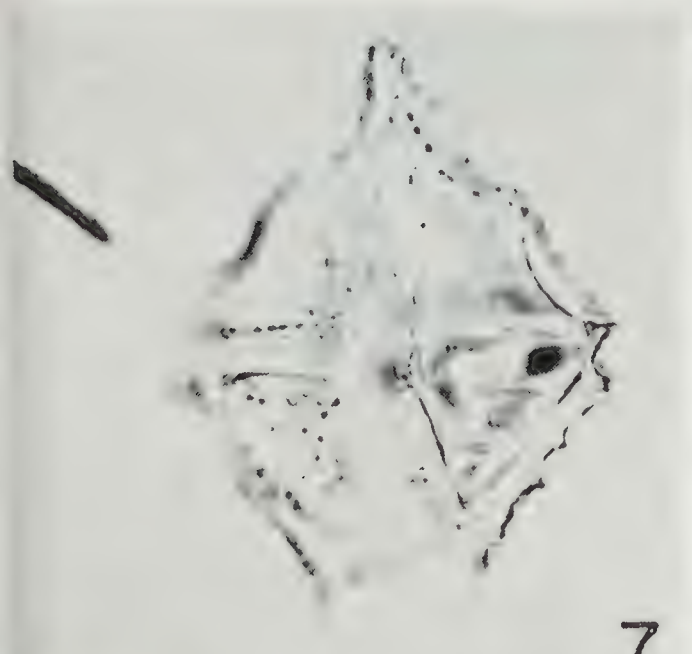
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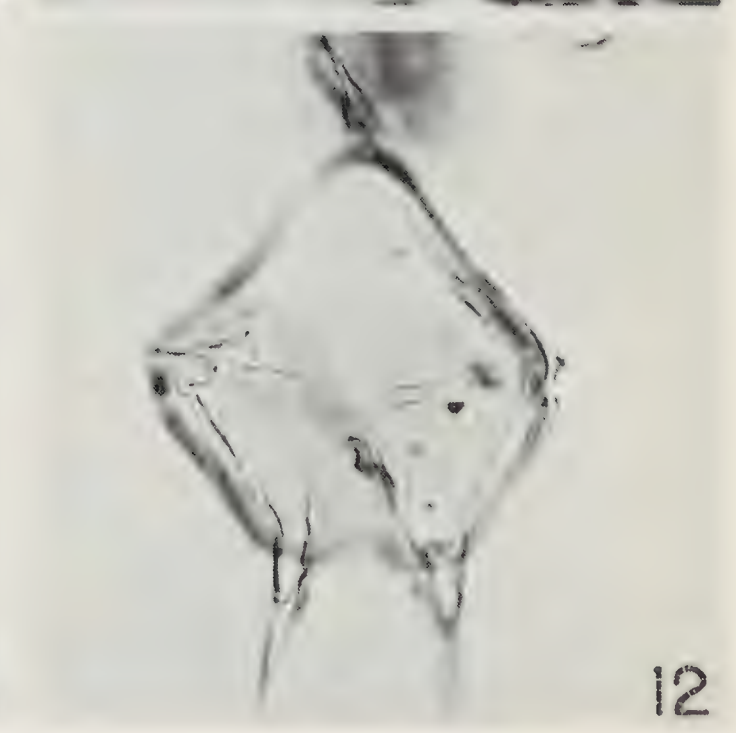
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PLATE 7

ack, 1968); Senonian, Australia (Deflandre and Cookson, 1955); Upper Cretaceous, Canada (Manum and Cookson, 1964; McIntyre, 1974); upper Campanian, Canada (Harland, 1973); Maestrichtian, Holland (Wilson, 1971); Danian, U.S.A. (Drugg, 1967).

CYCLOPSIELLA VIETA (?)
Drugg and Loeblich 1967

Plate 12, figures 8, 9

1967 *Cyclopsiella vieta* DRUGG and LOEBLICH, p. 192, plate 3, figure 7-9, text figure 8.

Comments: The specimens of *Cyclopsiella vieta(?)* recovered are generally broader than long. The equatorial fold reported by Drugg and Loeblich (1967) is not evident in these specimens. In some specimens the periphragm has very fine filaments on its outer surface extending not more than 1 micron off the surface. The filamentous extensions are random in distribution and their significance is not clear.

Dimensions: Ten specimens measured; overall length 45-49 micra; overall width 49-55 micra; endophragm thickness 1 micron; periphragm thickness less than 0.5 micron.

Occurrence: Very rare in samples 280-282, 285, 287, 289, 291-292, Monmouth Formation.

Previous Reported Occurrence: Oligocene, U.S.A. (Drugg and Loeblich, 1967).

Genus DICONODINIUM
Eisenack and Cookson 1960

DICONODINIUM RHOMBIFORMIS
Vozzhennikova 1967
Plate 12, figures 10-12

1967 *Diconodinium rhombiformis* VOZZHENNIKOVA, p. 50, plate 7, figures 1-4; plate 15, figure 5.

Comments: Diconodinium rhombiformis is present in the Monmouth samples. It appears to be nearly identical with the figured specimens of Vozzhennikova (1967).

PLATE 8

Page

Figures 1-3. *Deflandrea dartmooria* 192
Sample 287, slide AN 33, R 10.8, + 12.2. Periblast L x W 127 x 61 micra, endoblast L x W 86 x 56 micra. Figs. 1, 2: Ventral (transparency) and dorsal views respectively. Fig. 3: Illustration of ventral surface showing intratabular arrangement of coni on the epitract.

Figure 4-6. *Deflandrea diebelii* 192
Sample 281, slide AN 10, R 17.6, + 11.4. Periblast L x W 245 x 70 micra, endoblast L x W 68 x 65 micra. Figs. 4, 5: Dorsal and optical section views. An operculum is faintly visible on Fig. 4. Note the shape of the closely appressed endoblast. Fig. 6: Enlargement of dorsal surface to illustrate longitudinal wrinkles, faintly indicated cingulum, and outline of operculum.

Figures 7-9. *Deflandrea* cf. *D. diebelii* 192
Sample 286, slide AN 29, R 4, + 12.3. Periblast L x W 147 x 44 micra, endoblast L x W 59 x 38 micra. Figs. 7, 8: Dorsal (transparency) and ventral views respectively illustrating the archeopyle and faint indication of the sulcus. A concavo-convex flagellar scar (?) may be seen in Fig. 8. Fig. 9: Dorsal surface showing longitudinal striations, weakly impressed cingulum and faint microreticulate sculpture.

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PLATE 8

The cyst wall is single-layered and is faintly microreticulate. Tabulation could not be observed; however, very faint plate boundaries appeared to be present on the epitract. The cingulum is equatorial and is interrupted by a wide (up to 10 micra) sulcus, which extends up to 5 micra on the epitract. A concavo-convex flagellar scar is present in the sulcus. The apical process is distinctive, appears to be composed of intertwined fibers, and exhibits a braided appearance. A similar appearance is occasionally observed on the antapical process. The archeopyle is not observable on these specimens.

Dimensions: Ten specimens measured; overall length 35-44 micra; width 25-29 micra; apical process length 2-3 micra; antapical process length 1-4.5 micra; thickness of cyst wall about 0.5 micron.

Occurrence: Very rare to rare in samples 279-287, Monmouth Formation.

Previous Reported Occurrence: Turonian, U.S.S.R. (Vozzhennikova, 1967).

Genus FIBRADINIUM Morgenroth 1968

FIBRADINIUM cf. F. ANNETORPENSE Morgenroth 1968

Plate 13, figures 1-3

Comments: Specimens resembling *Fibradinium annetorpense* were distributed throughout the Round Bay section. They exhibited a tabulation of ?', ?a, 6'', 6c + 1tr, 6''', 1p, 1'''' which is different from the tabulation of Morgenroth. Many specimens were reoriented in an attempt to observe the apical tabulation; however, it is indeterminate. The archeopyle is apical (Type A). The

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PLATE 9

Page

Figures 1-3. *Deflandre* cf. *D. pentaradiata* 194
Illustrations showing intraspecific variation. Fig. 1: Sample 295, slide AN 67, R 11.8, + 10.2. Periblast L x W 126 x 105 micra, endoblast L x W 91 x 93 micra. Fig. 2: Sample 295, slide AN 65, R 9.1, + 5.3. Periblast L x W 126 x 93 micra, endoblast L x W 82 x 77 micra. Fig. 3: Sample 294, slide AN 63, R 11.6, + 5.2. Periblast L x W 121 x 103 micra, endoblast L x W 68 x 77 micra.

Figures 4-9. *Deflandrea pulchra* n. sp. 194
Figs. 4-7: Holotype, Sample 296, slide AN 69, R 3.7, + 6.2. Periblast L x W 69 x 50 micra, endoblast L x W 46 x 46 micra. Figs. 4-6: Dorsal (transparency), optical section and ventral views respectively. Fig. 7: Higher magnification to illustrate endoblast wall. Fig. 8: Paratype, Sample 297, slide AN 73, R 5.8, + 18.7. Periblast L x W 70 x 53 micra, endoblast L x W 50 x 49 micra. Dorsal view showing development of accessory sutures. Fig. 9: Paratype, Sample 295, slide AN 65, R 7.7, + 4.3. Periblast L x W 70 x 53 micra, endoblast L x W 47 x 47 micra. Dorsal view showing loss of precingular plate.

Figures 10-12. *Deflandrea rhombohedra* n. sp. 195
Holotype, Sample 294, slide AN 62, R 8.3, + 11.2. Periblast L x W 72 x 35 micra, endoblast L x W 49 x 33 micra. Figs. 10, 11: Dorsolateral, optical section views. Fig. 12: Enlargement of hypotract showing microreticulate surficial sculpture.

PLATE 9

questionable apical tabulation and differences in the remaining tabulation makes the definitive assignment to *F. annetorpense* questionable.

Dimensions: Eleven specimens measured; length 29-35 micra; width 25-33 micra; sutural crest height 2-3 micra.

Occurrence: Very rare to rare in samples 279-282, 285, 289, 292-297, Monmouth Formation and Brightseat Formation.

Genus FROMEA
Cookson and Eisenack 1958

FROMEA AMPHORA
Cookson and Eisenack 1958
Plate 15, figure 4

1958 *Fromea amphora* COOKSON and EISENACK, p. 56, plate 5, figures 10-11.

Comments: Specimens resembling *Fromea amphora* are encountered only in the lower portion of the Round Bay section. They, like the forms reported by Davey (1969a), differ from the specimens described by Cookson and Eisenack (1958) in that a cingulum is absent; however, they conform in other respects to the original description.

Dimensions: Six specimens measured; length 79-103 micra; width 58-72 micra.

Occurrence: Very rare in samples 279-282, Monmouth Formation.

Previous Reported Occurrence: Barremian, Germany (Alberti, 1961); Barremian, England (Sarjeant, 1966b); Lower Cretaceous, Canada (Singh, 1971); Aptian-Cenomanian, Australia (Cookson and Eisenack, 1958); Albian, France (Davey and Verdier, 1971); Albian-Cenomanian, England (Cookson and Hughes, 1964, Davey, 1969a); Albian, Canada (Brideaux, 1971); Cenomanian, France (Davey, 1969a); Upper Cretaceous, Canada (Manum and Cookson, 1964;

PLATE 10

Page

Figures 1-3. *Deflandrea severnensis* n. sp. 195
Holotype, Sample 288, slide AN 37, R 15.8, + 13.4. Periblast L x W 71 x 65 micra, endoblast L x W 52 x 61 micra. Dorsal, optical section, and ventral (transparency) views respectively.

Figures 4-6. *Deflandrea* cf. *D. speciosa* 196
Sample 290, slide AN 45, R 6, + 14.1. Periblast L x W 103 x 58 micra, endoblast L x W 60 x 55 micra. Figs. 4, 5: Dorsal (transparency), ventral views respectively. Fig. 6: Illustration to show the semi-linear arrangement of denticulated ridges.

Figures 7-9. *Deflandrea* sp. A 196
Sample 284, slide AN 22, R 13.2, + 11. Periblast L x W 86 x 61 micra, endoblast L x W 53 x 53 micra. Figs. 7, 8: Dorsal (transparency) and optical section views respectively. Fig. 9: Enlargement of optical section to show endoblast wall and short spines on periblast surface.

Figures 10, 11. *Palaeoperidinium basilium* 196
Sample 297, slide AN 73, R 16.3, + 16.2. L x W 119 x 104 micra. Dorsal (transparency) and ventral views respectively. The "growth lines" deliniating plate boundaries are apparent.

Figure 12. *Palaeoperidinium* cf. *P. deflandrei* 196
Sample 284, slide AN 21, R 16.5, + 13.3. L x W 105 x 89 micra. Dorsal view (transparency), plate boundaries barely discernable.

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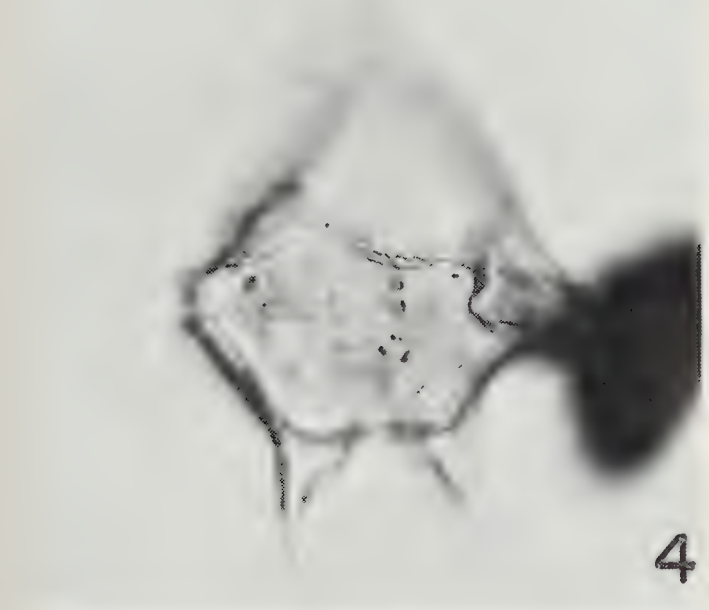
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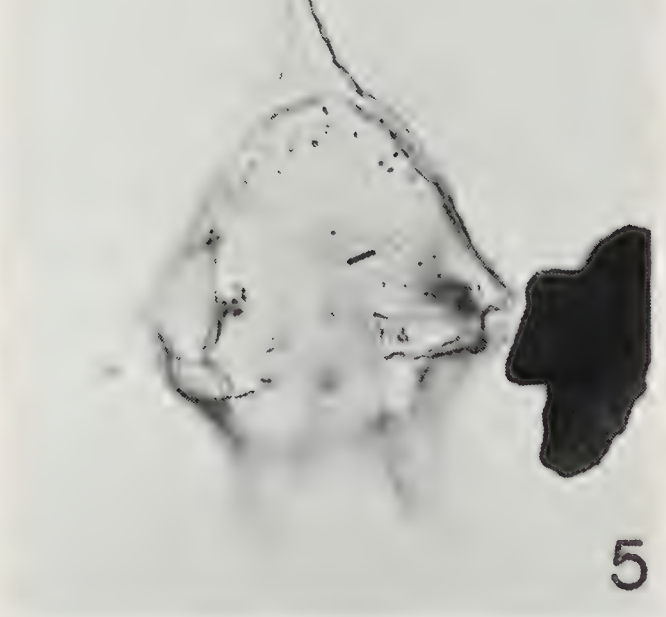
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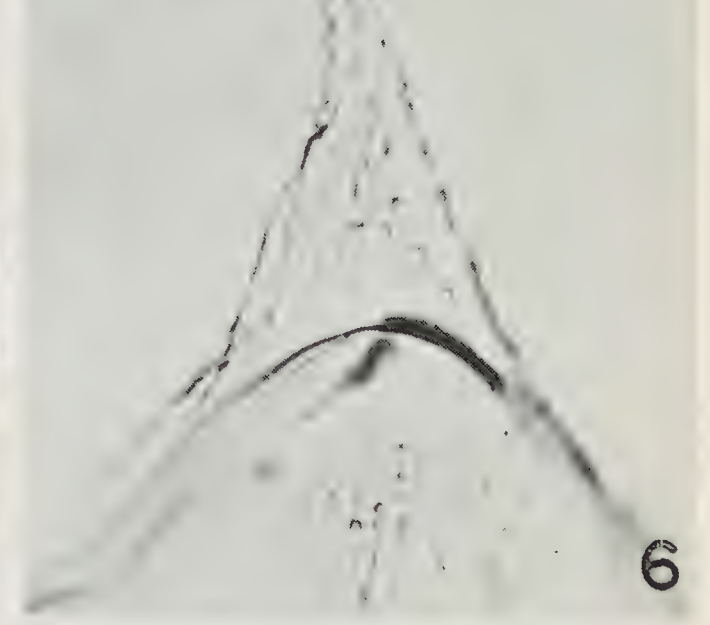
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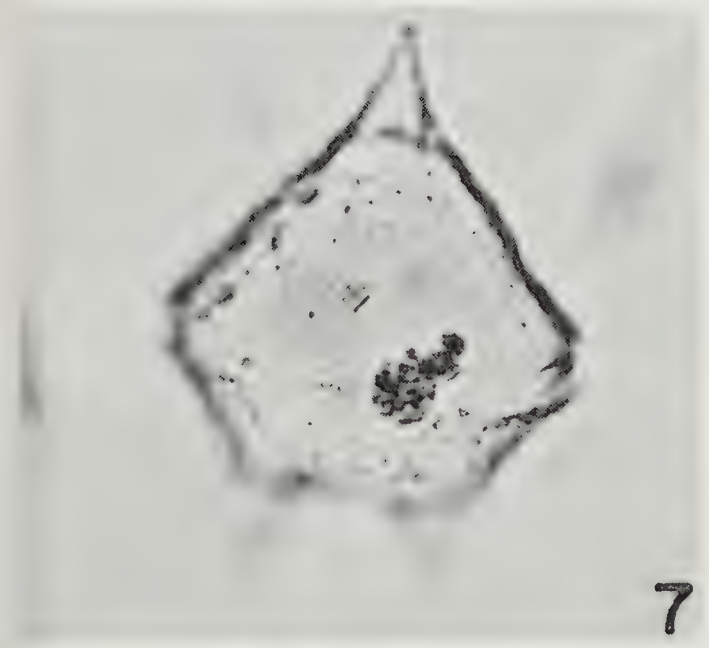
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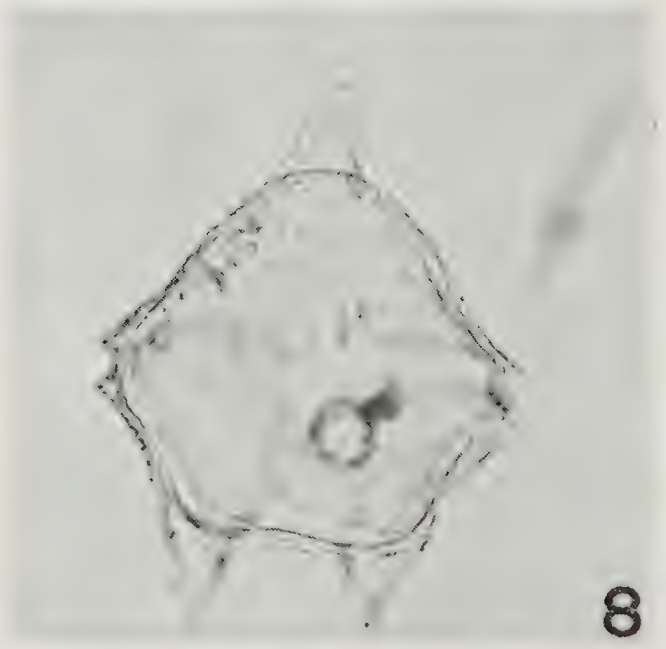
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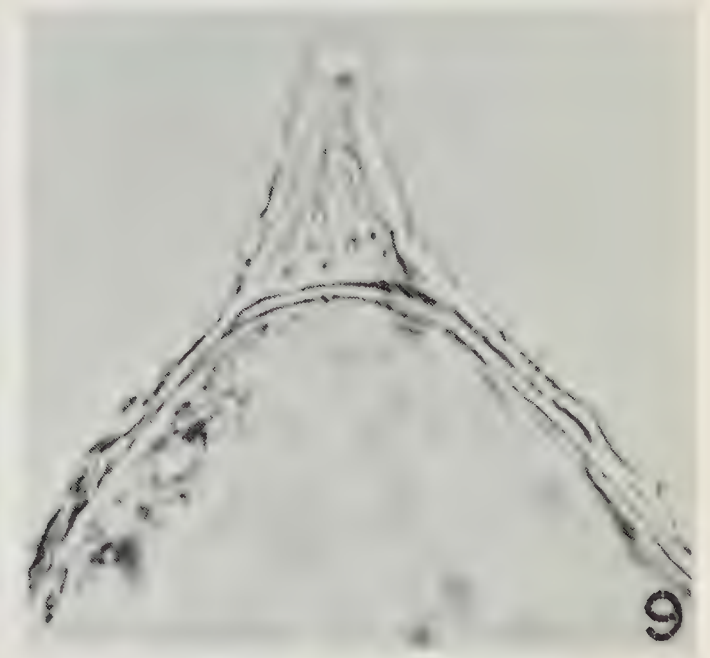
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PLATE 10

McIntyre, 1974); Upper Cretaceous, U.S.S.R. (Vozzhennikova, 1967).

Genus INVERSIDINIUM McLean 1973b

INVERSIDINIUM CAUDATUM n. sp.
Plate 13, figures 4-6

Derivation of name: cauda (L) tail, in reference to the elongate hypotract.

Holotype: Sample 292, slide AN 53, R 16.7 + 12.6.

Description: Bilayered cyst with peridinoid outline. Apex and antapex pointed to slightly rounded, hypotract longer than epitract. Tabulation absent. Periphragm exhibits microreticulate sculpture, both periphragm and endophragm less than 0.5 micron thick. Sulcus (?) and cingulum (?) reflected by evaginations of periphragm. Endoblast roughly triangular in shape, broader than long, and confined to hypotract. Archeopyle indeterminate.

Dimensions:

Holotype: length 54 micra; width 47 micra.

Range: 14 specimens measured; length 40-68 micra; width 35-56 micra.

Comments: Inversidinium caudatum does not exhibit a defined archeopyle. It is thought to be posterior in position and may be formed by transverse fission of the hypotract. A small pore is frequently seen to be associated with the antapex; however, its possible function in excystment is not clear.

Comparison with other species: Inversidinium caudatum resembles *I. exilimurum* (McLean, 1973b). Both species possess the periphragm evaginations and trinagular endoblast which is restricted to the hypotract; however, the hypotract of *I. exilimurum* is

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PLATE 11

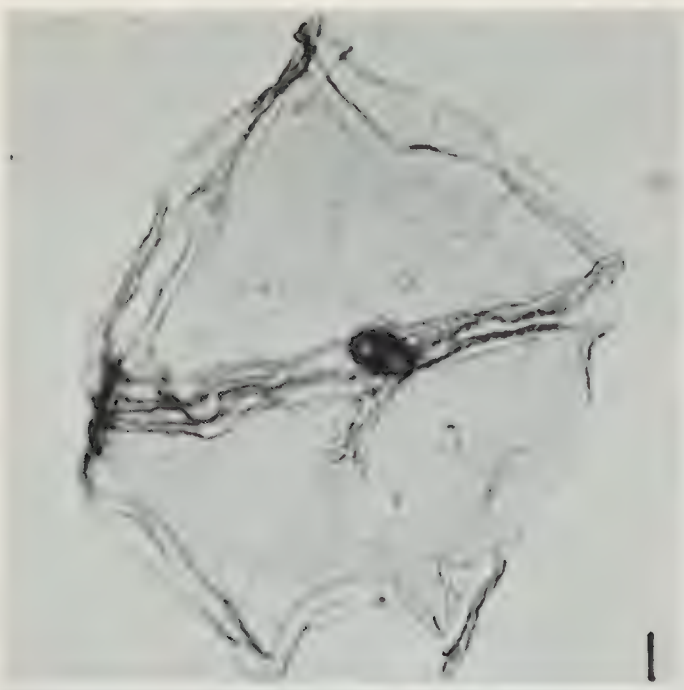
Page

Figure 1. *Palaeoperidinium* cf. *P. deflandrei* 196
Ventral view of same specimen as plate 10, Fig. 12.

Figures 2, 3. *Spinidinium clavum* 196
Sample 295, slide AN 65, R 20.5, + 2.6. Periblast L x W 51 x 35 micra, endoblast L x W 33 x 31 micra. Dorsolateral (transparency) and ventrolateral views respectively. The peritabular arrangement of the spines is clear.

Figures 4-8. *Trithyrodinium striatum* n. sp. 197
Figs. 4-6: Sample 281, slide AN 9, R 18.3, + 7.6. Periblast L x W 82 x 73 micra, endoblast L x W 65 x 62 micra. Dorsal, ventral (transparency) and optical section views respectively. Note the 3I archeopyle, striated endoblast and delicate periblast. Fig. 7: Sample 281, slide AN 9, R 13.5, + 6.4. L x W 65 x 60 micra. Isolated endoblast with operculum (by transparency) still in place. Fig. 8: Sample 281, slide AN 10, R 9.6, + 7. L x W 67 x 59 micra. Typical specimen with 3I archeopyle and periblast crumpled.

Figures 9-12. *Trithyrodinium robustum* n. sp. 198
Holotype, Sample 281, slide AN 9, R 15.9, + 6.4. Periblast L x W 153 x 78 micra, endoblast L x W 69 x 71 micra. Figs. 9-11: Dorsal (transparency), optical section, and ventral views respectively. The outline of plate equivalents on Fig. 9 is clear and shows the postion of the 2a archeopyle with operculum still in place. Fig. 12: Endoblast all showing the granular mesoblast (?).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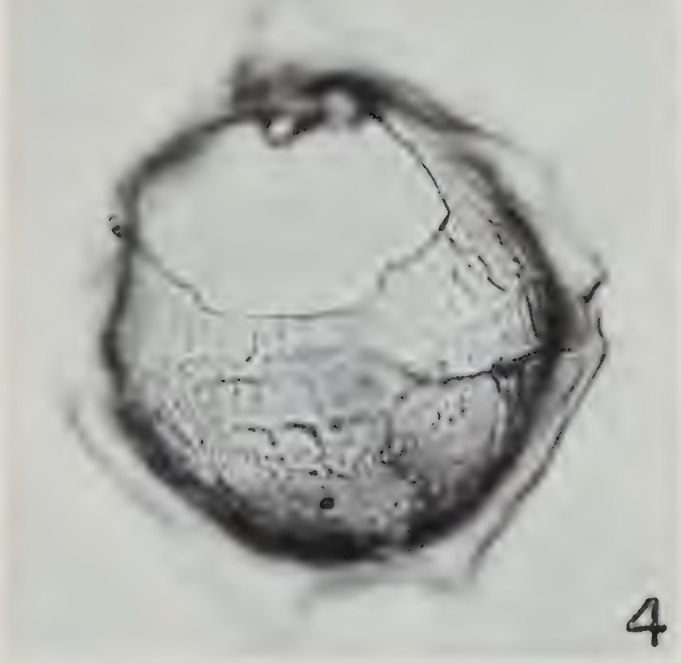
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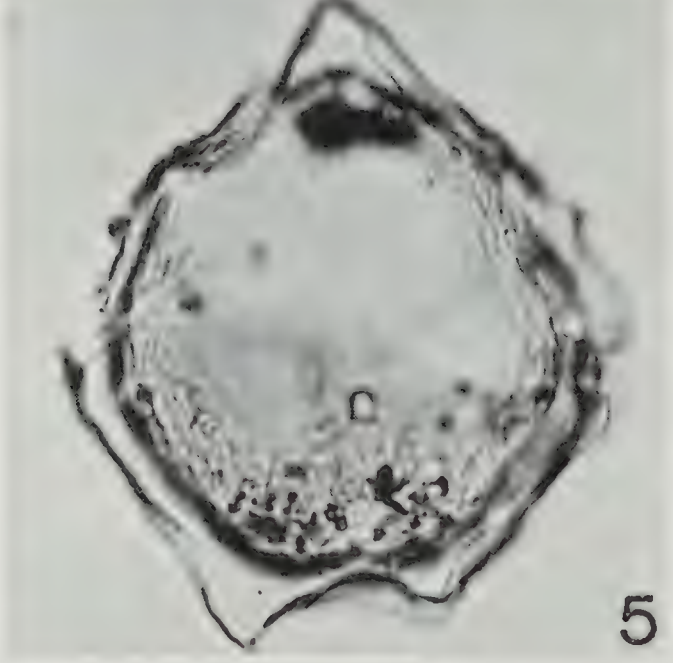
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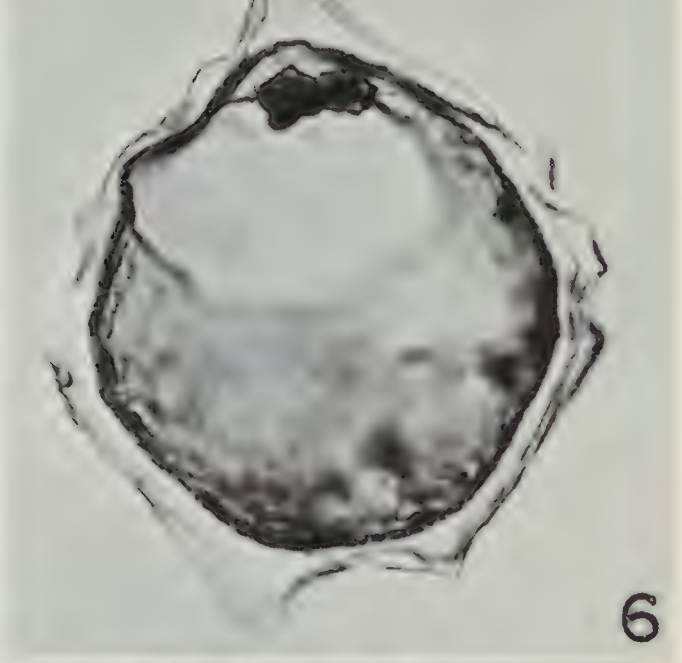
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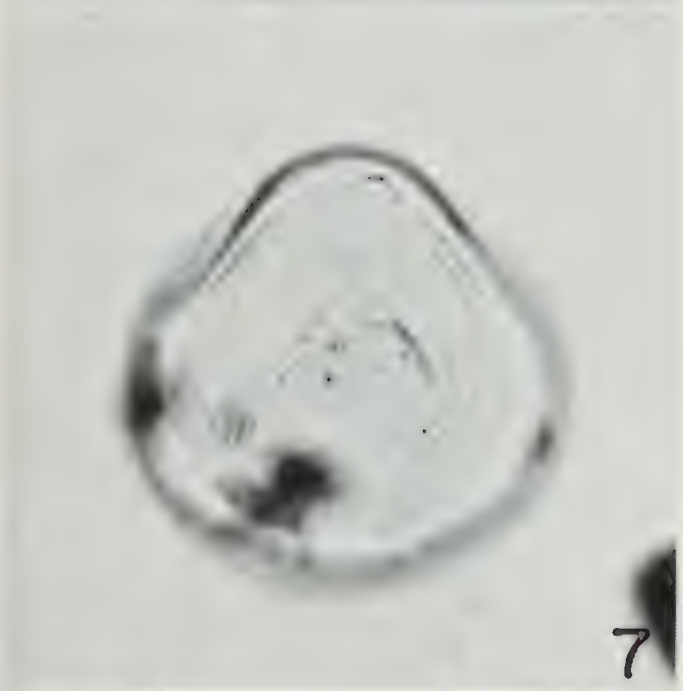
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PLATE 11

strongly truncated as opposed to the elongate hypotract of *I. caudatum*.

I. caudatum strongly resembles *Paleotetradinium silicorum* (Deflandre, 1936) in size, shape, and its stratigraphic position. However, the original description by Deflandre (1936) does not mention an archeopyle or excystment structure, or the presence and/or shape of the endoblast. Until a re-examination is done of the type of *P. silicorum,* or of topotype material, it is thought best to treat *I. caudatum* as a distinctive form.

Occurrence: Very rare to rare in samples 280, 281, 286, 288-292, 294, 295, 297, Monmouth Formation and Brightseat Formation.

Genus MICRODINIUM
Cookson and Eisenack 1960
emend. Sarjeant 1966

MICRODINIUM SETOSUM Sarjeant, 1966
Plate 13, figures 7-9

1966 *Microdinium setosum* SARJEANT, p. 151, plate 16, figures 9, 10, text figure 39.
1967 *Microdinium echinatum* CLARKE and VERDIER, p. 64, plate 1, figures 9, 10, text figure 26.
1967 *Microdinium dentatum* VOZZHENNIKOVA, p. 94, plate 38, figure 2.

PLATE 12

Page

Figure 1. *Trithyrodinium robustum* n. sp. 198
Holotype, Illustration of surface of endoblast. The 3I operculum is faintly visible and is still in place.

Figures 2, 3. *Wetzeliella* cf. *W. pilata* 202
Fig. 2: Sample 294, slide AN 61, R 14, + 5. L x W 60 x 45 micra. Dorsal (transparency) view. Fig. 3: Sample 295, slide AN 68, R 9.1, + 7.5. Spine morphology. The termination is identical to that illustrated by Stanley (1965).

Figures 4-6. *Areoligera* spp. 204
Sample 284, slide AN 21, R. 12, + 9.7, Cyst diameter 51 micra, processes up to 19 micra long. Dorsal, optical section and ventral (transparency) views respectively. An apical operculum is present, the lack of processes on the ventral surface is apparent.

Figure 7. *Cyclonephelium distinctum* 206
Sample 280, slide AN 6, R 18, + 3.1. Cyst diameter 42 micra, processes up to 7 micra long. Dorsal view. An apical archeopyle is present.

Figures 8, 9. *Cyclopsiella vieta(?)* 212
Sample 280, Slide AN 7, R 19.4, + 13.6. L x W 47 x 50 micra. Dorsal and ventral (transparency) views respectively. The circular aperture (archeopyle?) is readily visible on the dorsal surface.

Figures 10-12. *Diconodinium rhombiformis* 212
Sample 281, slide AN 10, R 16.8, + 8.6. L x W 44 x 25 micra. Dorsal, optical section and ventral (transparency) views respectively. The faint outline of plate equivalents is apparent.

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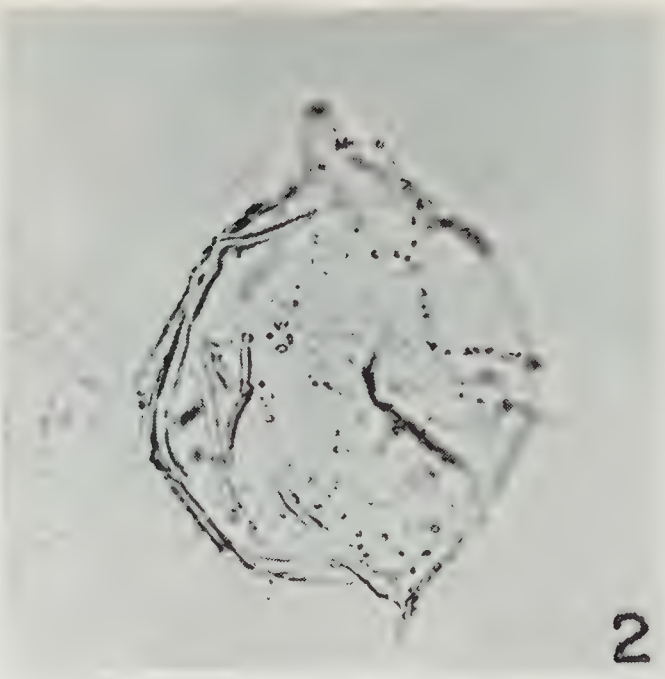
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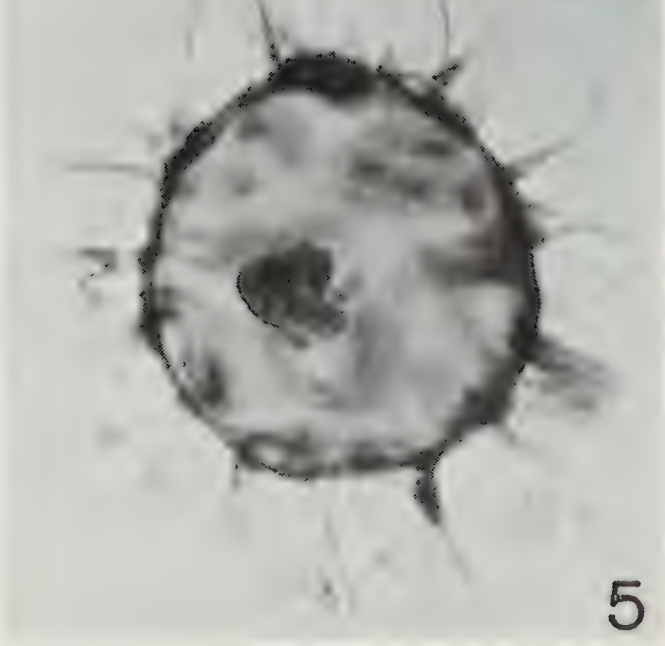
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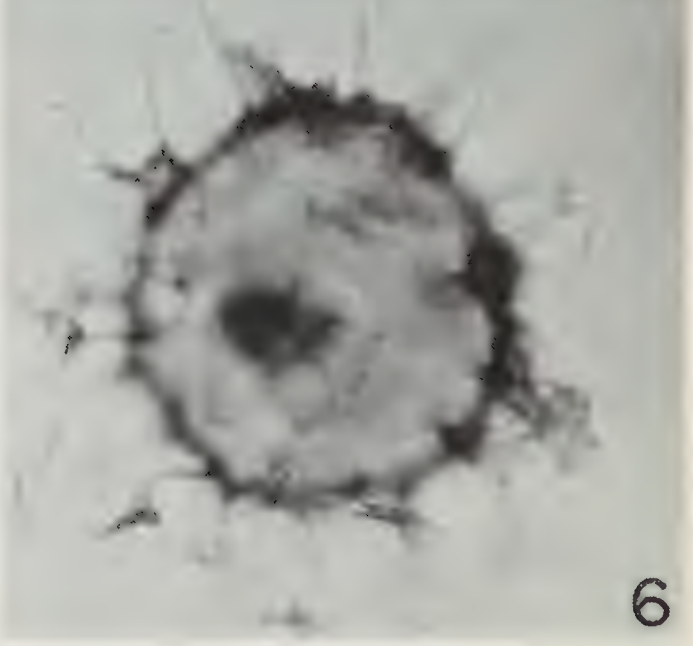
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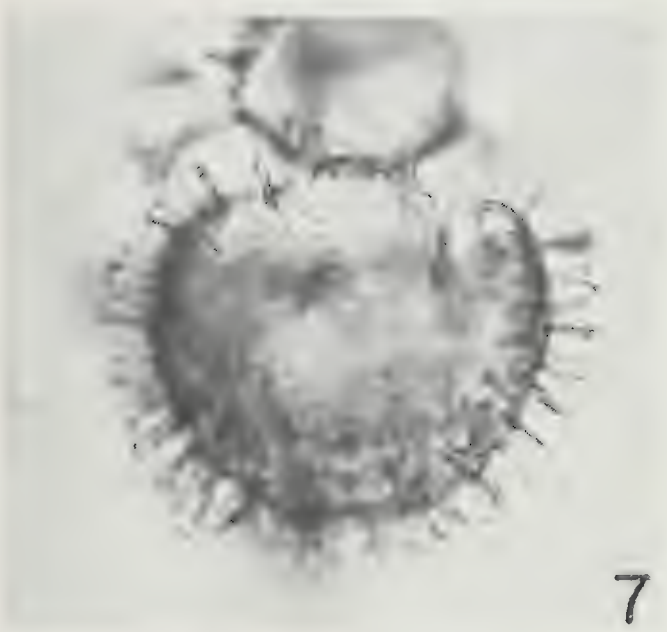
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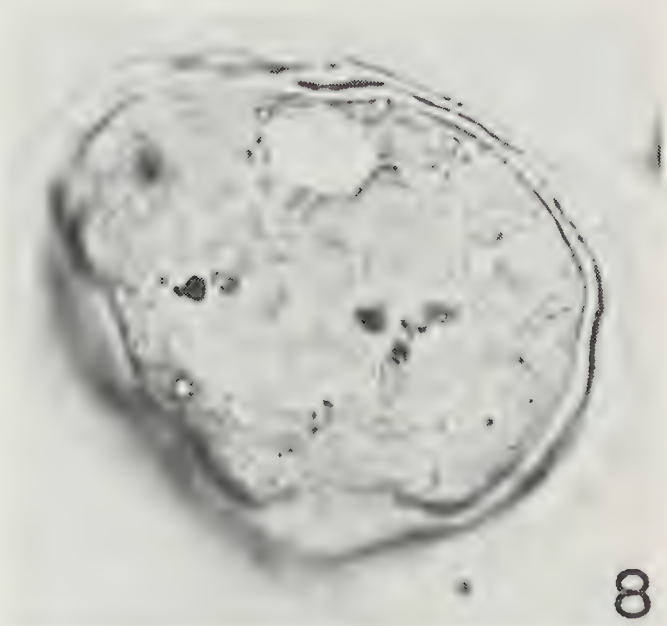
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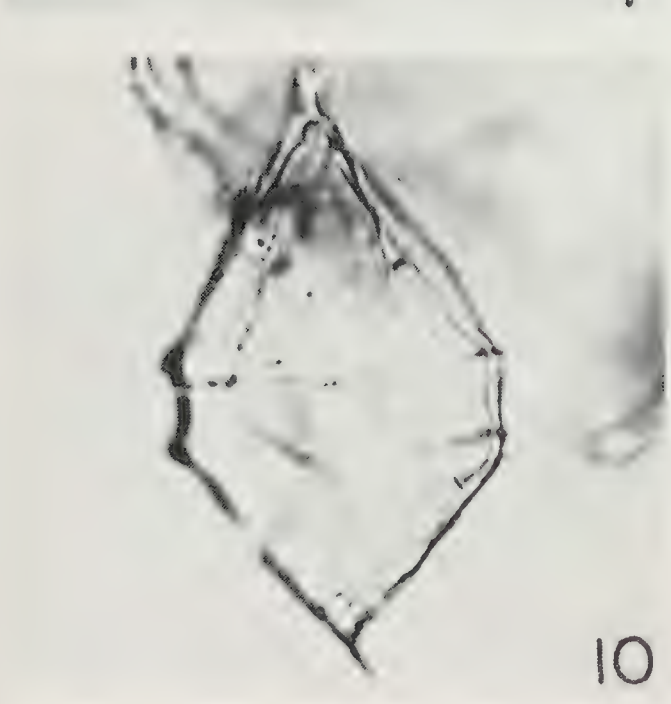
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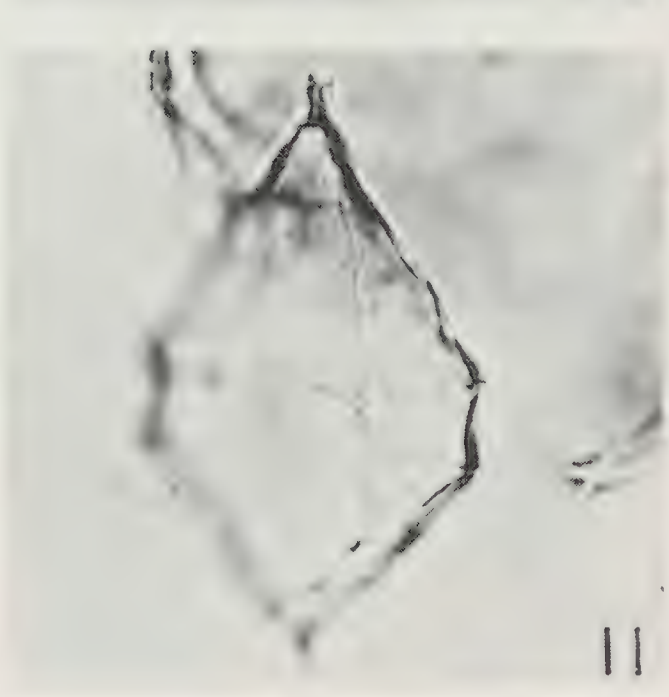
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PLATE 12

1969a *Microdinium setosum* Sarjeant; DAVEY, p. 133, plate 2, figure 4, text figure 13H.

Comments: Several specimens of *Microdinium setosum* were recovered, one of which is badly crumpled. The specimens are somewhat smaller than the originally described forms but resemble them in most aspects except that the tabulation observed on the single intact specimen differs from that given by Sarjeant (1966) and is similar to that described by McLean (1973a). Sarjeant's (1966) tabulation was ?1', 0a, 6", 6c, 6"', 1p, 1''''. The tabulation observed on the Monmouth specimen was ?', ?a, 7", 7c (or 6c + 1/tr), 6"', 1p, 1''''. In addition, at least two sulcal plate equivalents appear to be present (1 anterior, 1 posterior). An examination of text figure 39 of Sarjeant (1966) clearly shows the seventh cingular (or transitional) plate equivalent, which apparently was not recognized as such by that author. The seventh precingular plate equivalent is not evident on either text figure 39 or the photographs of the holotype (Sarjeant, 1966). Although only a single specimen illustrates tabulation clearly, it is felt by the author that such information should be presented in hopes of assisting in the resolution of tabulation discrepancies. The archeopyle is apical (Type A).

Dimensions: Nine specimens measured; length 27 micra; width 25 micra; crest height up to 3 micra; spine length 2 micra.

Occurrence: Very rare in samples 280, 281, 286, Monmouth Formation.

Previous Reported Occurrence: Albian-Cenomanian, England (Clarke and Verdier, 1967; Sarjeant, 1966a; Davey, 1969a); Albian, France (Davey and Verdier, 1971); Cenomanian, France (Davey, 1969a).

Genus A

Plate 13, figures 10-12; Plate 14, figure 1

Description: Proximate cyst, subspherical to oval with plate boundaries reflected by sutural crests. Wall bilayered, 1-1.5 micra

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PLATE 13

Page

Figures 1-3. *Fibradinium* cf. *F. annetorpense* 214
Sample 294, slide AN 61, R 6.3, + 17.2. L x W 32 x 28 micra. Dorsal (transparency), optical section and ventral views respectively.

Figures 4-6. *Inversidinium caudatum* n. sp. 218
Holotype, Sample 292, slide AN 53, R 16.7, + 12.6. L x W 54 x 47 micra. Dorsal, optical section and ventral (transparency) views respectively. The microreticulate surficial sculpture is apparent as is the longitudinal evagination (= sulcus?). On Fig. 6. a faint indication of the distal pore on the hypotract is present.

Figures 7-9. *Microdinium setosum* 220
Sample 280, slide AN 8, R 17.3, + 12.4. L x W 27 x 25 micra. Dorsal (transparency), optical section and ventral views respectively. The details of tabulation in the sulcal region are apparent.

Figures 10-12. Genus A 222
Sample 283, slide AN 19, R 20.7, + 15, Diameter 40 micra. Dorsal, optical section and ventral (transparency) view respectively. The columnar support for the periphragm is evident at 9:30 and 7 o'clock on Fig. 11. See also Plate 14, Fig. 1.

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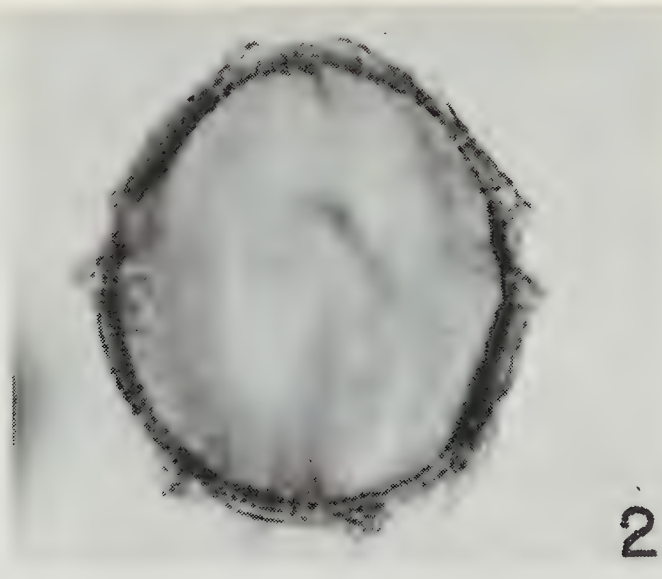
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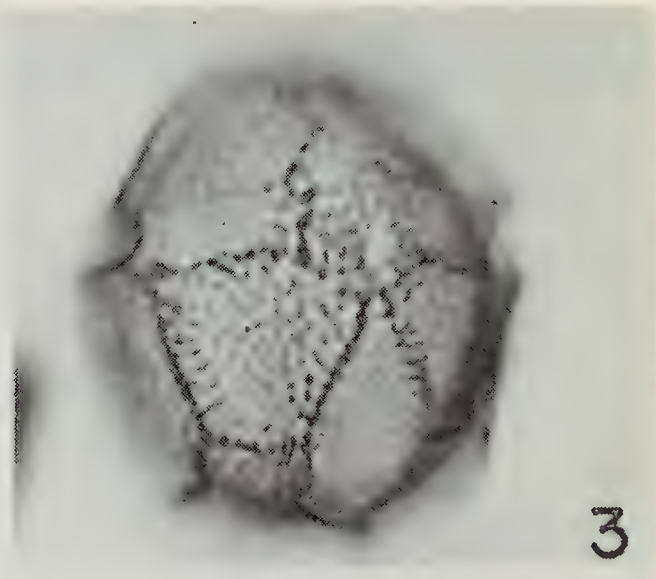
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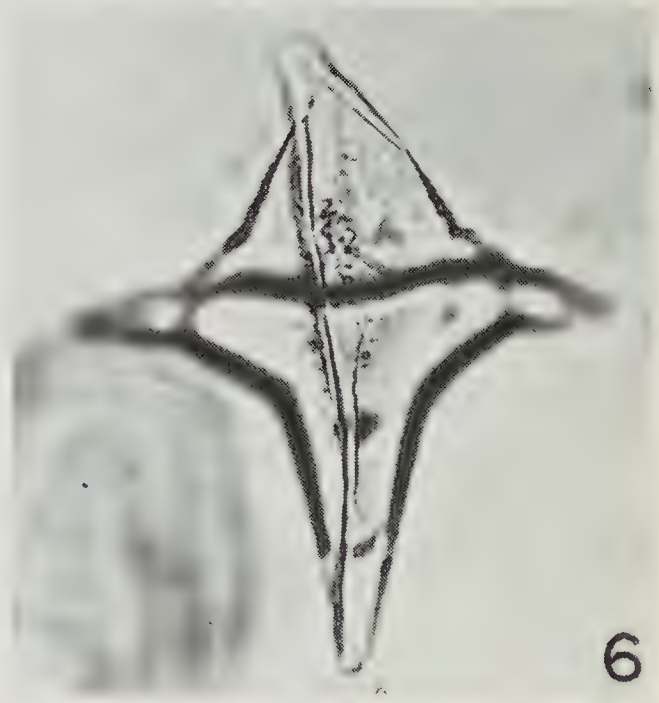
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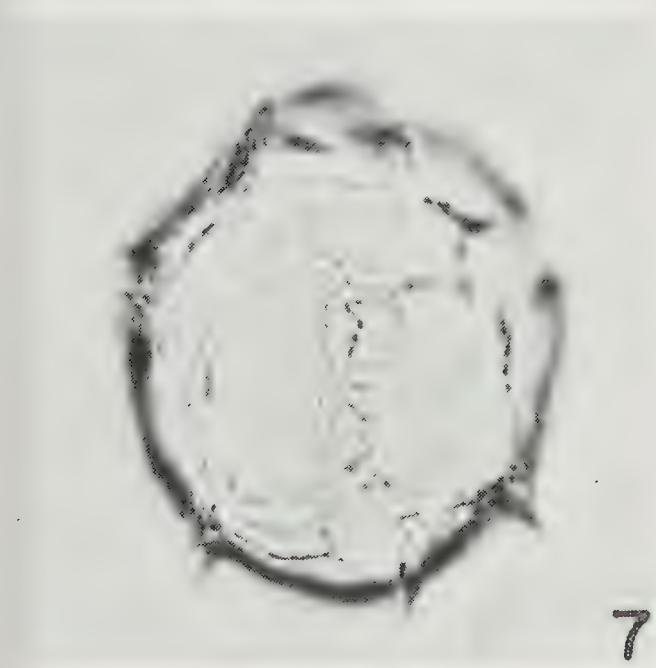
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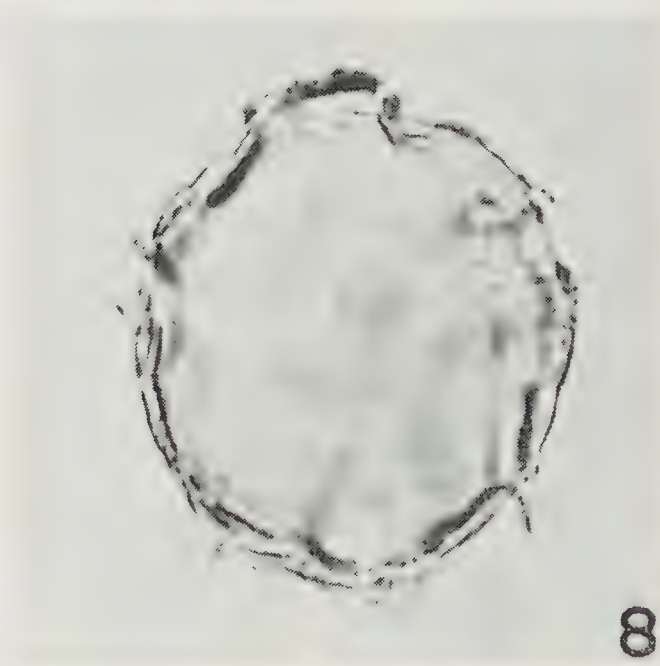
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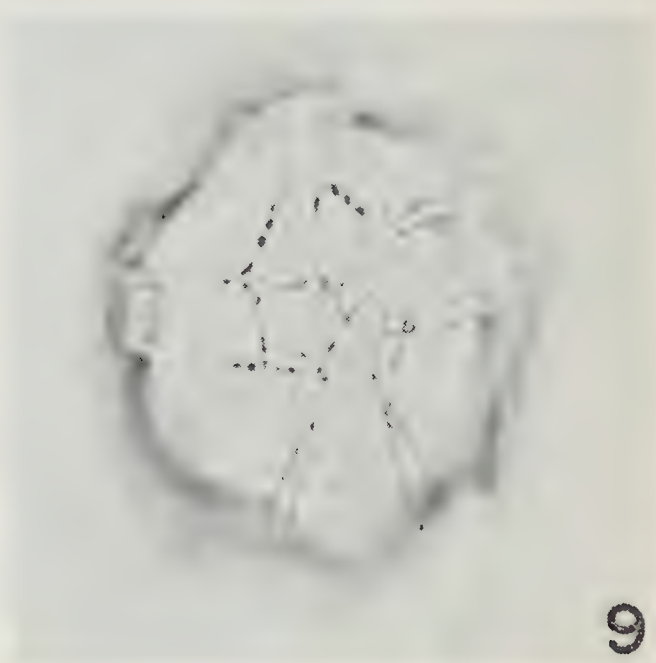
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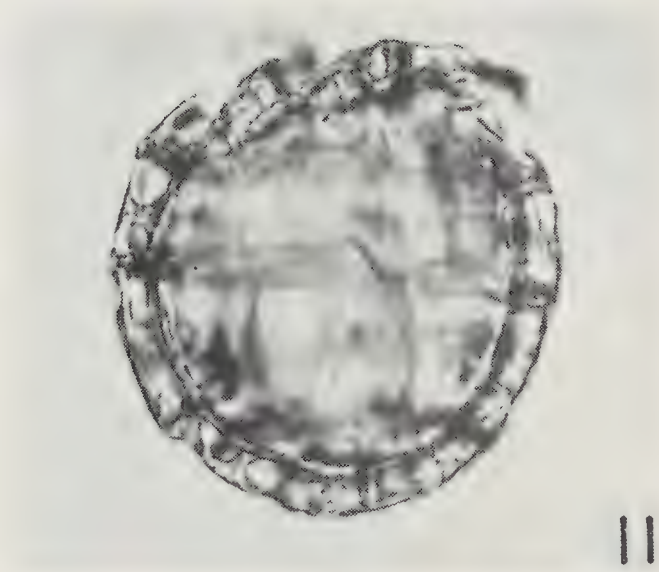
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PLATE 13

thick with periphragm apparently being supported by a columnar structure emanating from the endophragm. Reflected tabulation of ?', ?a, 7'', 6c + 1 tr., 6''', ?2p, 1''''. Archeopyle apical, cingulum slightly dextrorotary, offset less than one half cingulum width. Distinctive ornamentation located roughly in center of plate support.

Comments: Although certainly a member of the Microdiniaceae, the placement of this species in *Microdinium* is uncertain. The apparent supportive structure emanating from the endophragm is certainly a fundamental difference in this species' mode of construction from the normal *Microdinium*. This, coupled with the incomplete apical tabulation, makes the author hesitant to treat this species in a more complete taxonomic sense. This species is under investigation in a study separate from this work.

Dimensions: Six specimens measured; length 36-43 micra; width 35-40 micra; height of sutural crests 3-4.5 micra.

Occurrence: Very rare in samples 279-283, 295, Monmouth and Brightseat Formations. The single specimen recovered from sample 295 is somewhat altered and may be reworked from the Monmouth Formation.

PLATE 14

Page

Figure 1. Genus A 222
Enlargement of optical section illustrating columnar support of periphragm.

Figures 2-5. Genus B 226
Sample 279, slide AN 3, R 5.0, + 9.0. L x W 27 x 25 micra. Figs. 2-4: dorsal (transparency), optical section and ventral views respectively. The arch of the periphragm is evident in Fig. 5, an enlargement of the optical section.

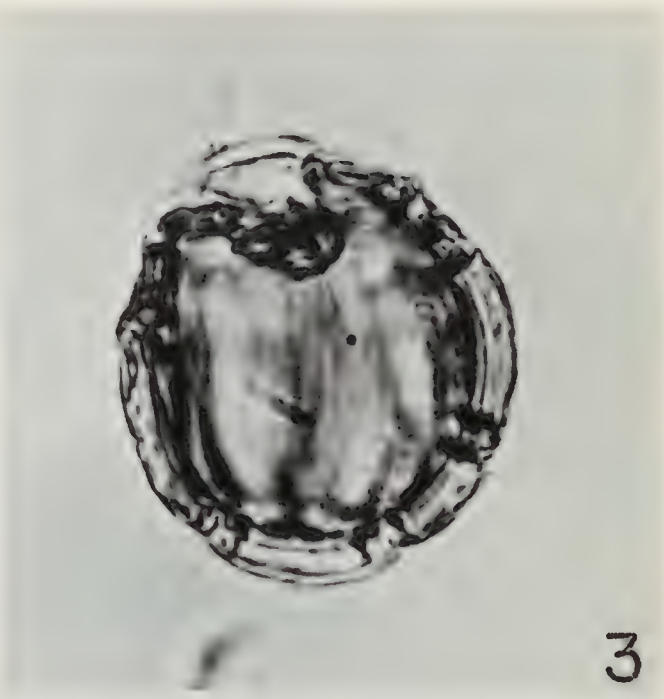
Figures 6, 7. *Systematophora* cf. *S. areolata* 226
Sample 285, slide AN 25, R 5.8, + 7.9. Cyst diameter 49 micra, processes up to 26 micra long. Apical and antapical (transparency) views respectively.

Figures 8, 9. *Systematophora placacantha* 228
Sample 285, slide AN 25, R 5.8, + 7.9. Cyst diameter 49 micra, processes up to 20 micra long. Dorsal and ventral (transparency) views respectively.

Figure 10. *Tanyosphaeridium variecalamum* 228
Sample 293, slide AN 60, R 17.5, + 17.8. Cyst L x W 29 x 17 micra, processes up to 14 micra. Dorsal view. Note the apical archeopyle.

Figure 11. *Xenikoon australis* 228
Sample 281, slide AN 9, R 3.6, + 12.7. L x W 77 x 58 micra. Dorsal view.

Figure 12. *Ophiobolus lapidaris* 228
Sample 285, slide AN 25, R 14.2, + 2.8. L x W 37 x 16 micra. Illustration showing microreticulate surficial sculpture. Pseudoflagella coiled on surface.



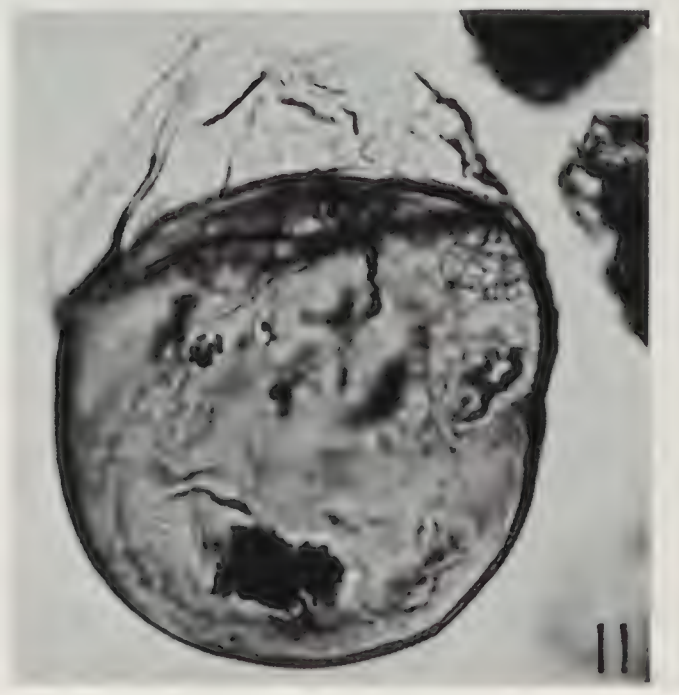


PLATE 14

Genus B
Plate 14, figures 2-5

Description: Proximate cyst, subspherical to oval. Plate boundaries reflected by low arch of periphragm. Boundaries may be complete or variably dissected. The region between the arch and the endophragm appears hollow. Reflected tabulation of ?', ?a, 6'', 6c + 1 tr, 6''', 1p, 1''''. Archeopyle apical, hexagonal in outline. Cingulum nonrotary. Wall bilayered 1.5-2 micra thick. Endophragm exhibits variably developed microreticulate sculpture. Periphragm appears restricted to the low arches.

Comments: Although certainly allied with the Microdiniaceae, this species differed in its construction from *Microdinium*. The low arches formed by the periphragm with the apparently hollow space beneath the arch separating the periphragm and endophragm is distinctive. Due to the low recovery and incomplete apical tabulation the author feels that more complete taxonomic treatment would be premature. This species does appear to be a good indicator of lower Monmouth sediments. This species is under investigation in a study separate from this work.

Dimensions: Six specimens measured; length 26-28 micra; width 25-26 micra; arch height about 2 micra.

Occurrence: Very rare in samples 279, 280, 281, Monmouth Formation.

Genus SYSTEMATOPHORA Klement 1960

SYSTEMATOPHORA cf. S. AREOLATA
Klement 1960
Plate 14, figures 6, 7

Comments: Cysts very similar to those described by Klement (1960) occur in the Monmouth Formation. They possess a greater number of processes per field than was apparent in Klement's figures; however, the tabulation of ?', 6'', 6c, 4''', 1-2p, 1'''' agreed with that published by Klement (1960). The archeopyle is apical (Type A).

Dimensions: Five specimens measured; main cyst body diameter 58-60 micra; process length up to 25 micra.

Occurrence: Very rare in samples 283, 285, Monmouth Formation.

PLATE 15

Page

Figures 1-3. *Dinogymnium* sp. 180
Sample 289, slide AN 42, R 14, + 9. L x W 171 x 23 micra. Fig. 1: Dorsal view. Fig. 2: enlargement illustrating the high cingulum and faint sulcus. Fig. 3: wall morphology. Note the punctate surface.

Figure 4. *Fromea amphora* 216
Sample 281, slide AN 10, R 8.5, + 11.6, L x W 82 x 58 micra. Specimen showing the aperture (archeopyle ?).

Figures 5, 6. *Svalbardella australina* 197
Sample 286, slide AN 29, R 9.2, + 16.6. Periblast L x W 89 x 56 micra, Endoblast L x W 114 x 51 micra. Dorsolateral and optical section views. An intercalary archeopyle is visible. The accessory spike is well developed.

Figures 7-9. *Deflandrea* cf. *D. striata* 180
Sample 293, slide AN 60, R 5.1, + 16.2. L x W 170 x 80 micra. Figs. 7, 8: Dorsal (transparency) and ventral views respectively. Fig. 9: Enlargement to illustrate the longitudinal striations.

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PLATE 15

SYSTEMATOPHORA PLACACANTHA
(Deflandre and Cookson)
Davey *et al.* 1969
Plate 14, figures 8, 9

1955 *Hystrichosphaeridium placacanthum* DEFLANDRE and COOKSON, p. 276, plate 19, figures 1-3.
1963 *Baltisphaeridium placacanthum* (Deflandre and Cookson) DOWNIE and SARJEANT, p. 92.
1969 *Systematophora placacantha* (Deflandre and Cookson) DAVEY, DOWNIE, SARJEANT and WILLIAMS, p. 17.

Comments: The specimens of *S. placacantha* resemble the original description. Most specimens are poorly preserved. The fields of processes are not defined on the ventral surface and tabulation is indeterminate; however, the accessory sutures of the apical archeopyle (Type A) indicate the presence of six precingular plate equivalents.

Dimensions: Five specimens measured; cyst main body diameter 58-65 micra; process length 14-21 micra.

Occurrence: Very rare to common in samples 283, 285, Monmouth Formation.

Previous Reported Occurrence: Upper Cretaceous, Germany (Gocht, 1959); Early Cenozoic, S.E. Australia, W. New Zealand (Haskell and Wilson, 1975); lower Eocene, N. Germany, Belgium (Morgenroth, 1966); middle-upper Oligocene, Germany (Benedek, 1972); Miocene, Australia (Deflandre and Cookson, 1955).

Genus TANYOSPHAERIDIUM
Davey and Williams 1966b

TANYOSPHAERIDIUM VARIECALAMUM
Davey and Williams 1966b
Plate 14, figure 10

1966b *Tanyosphaeridium variecalamum* DAVEY and WILLIAMS, p. 98, plate 6, figure 7, text figure 20.

Comments: The specimens of *Tanyosphaeridium variecalamum* conform precisely to the original description. No complete specimens were recovered, all having lost the apical operculum.

Dimensions: Ten specimens measured; cyst body length 28-30 micra; width 16-17 micra; process length 12-14 micra.

Occurrence: Very rare to rare in samples 284, 291-293, 295, Monmouth Formation and Brightseat Formation.

Previous Reported Occurrence: Albian, Canada (Davey, 1969a); Albian, France (Davey and Verdier, 1971); Albian-Turonian, England (Davey and Williams, 1966b; Davey, 1969a); Cenomanian, France (Davey, 1969a); upper Campanian, Canada (Harland, 1973).

Genus XENIKOON
Cookson and Eisenack 1960

XENIKOON AUSTRALIS
Cookson and Eisenact 1960
Plate 14, figure 11

1960 *Xenikoon australis* COOKSON and EISENACK, p. 16, plate 3, figures 16-17.

Comments: The specimens of *Xenikoon australis* recovered in this study conform to the original description; however, an archeopyle is not observable in the Monmouth specimens.

Dimensions: Ten specimens measured; periblast length 52-75 micra; width 40-58 micra; endoblast length 40-56 micra; width 40-56 micra; apical pericoel 11-18 micra.

Occurrence: Very rare to rare in samples 280-286, 288, Monmouth Formation.

Previous Reported Occurrence: Cretaceous, Australia (Cookson and Eisenack, 1960).

Phylum PROTOZA
Family OPHIOBOLIDAE Deflandre 1952
Genus OPHIOBOLUS Wetzel 1933

OPHIOBOLUS LAPIDARIS Wetzel 1933
Plate 14, figure 12

1933 *Ophiobolus lapidaris* WETZEL, p. 167, plate 2, figures 5-7.
1967 *Scuticabolus lapidaris* (Wetzel) LOEBLICH, p. 68.
1968 *Ophiobolus lapidaris* Wetzel; EVITT, p. 4, plate 1, text figures 1-6.

Comments: Specimens of *Ophiobolus lapidaris* identical to those described by Wetzel (1933) were observed in the Monmouth Formation. They are frequently found to be entangled by their pseudoflagellae in clumps of *Spiniferites* and *Hy-*

strichosphaeridium. It is considered to be an excellent Upper Cretaceous marker in Maryland sediments.

Dimensions: Ten specimens measured; length 37-42 micra; width 12-18 micra; pseudoflagellae up to 90 micra in length.

Occurrence: Rare to very rare in samples 280-287, 289-293, Monmouth Formation.

Previous Reported Occurrence: Upper Cretaceous, Germany (Wetzel, 1933); Upper Cretaceous, U.S.A. (Evitt, 1968); Upper Cretaceous, Canada (McIntyre, 1974); Danian, N. Europe (Morgenroth, 1968).

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REVIEW

GEOTHERMICS, by Jean Goguel. Translated from the French edition by Alan Rite, and edited by Sydney P. Clark, Jr. Published by Mc-Graw Hill Book Company, New York, 1976, xi + 200 pp., $15.00

This book is an English edition of *La Géothermie,* originally published in Paris. It is intended as an advanced text and reference book which covers the theories, practical exploration, and economics of geothermal energy. The text deals with first principles and the thermal regime near the earth's surface with particular attention to the interaction between the temperature field and circulating ground waters. The practical and political problems of extracting usable heat and power from geothermal sources are discussed and the operation of generating plants is described. Many subjects of direct interest to earth scientists are included throughout this work.

—H.C.S.

REVIEWS

HUBERT C. SKINNER
TULANE UNIVERSITY

FATHER OF TEXAS GEOLOGY, Robert T. Hill, by Nancy Alexander. Published by the Southern Methodist University Press, Dallas, Texas, 1976, xii + 317 pp., illus., $12.50

Robert T. Hill, pioneer Texas geologist, discoverer of the Comanche Series (Lower Cretaceous), and lifelong student of the structure and stratigraphy of the Texas Cretaceous, is one of the most significant figures in the development of American geology in the late nineteenth century and the early part of the twentieth century. He was the first to recognize the two-fold subdivision of the Cretaceous System, and the names which he introduced, Comanchean and Gulfian, are now applied throughout the Gulf Coast area. His subdivision of the Lower Cretaceous strata into groups and formations is the standard for stratigraphic nomenclature in the western Gulf Coast region. Near the turn of the century, he conducted studies in the West Indies and the Isthmus of Panamá, areas he considered fundamental to understanding the geological evolution of North America. In 1902, following the eruption of Mont Pelée, Hill joined the relief expedition to Martinique that sailed on the U.S.S. *Dixie*. He mapped the destruction area and wrote the first account of the Peléan cloud, the *nuée ardente,* previously unknown to vulcanologists. In his last years, Robert T. Hill lived in Dallas and devoted much of his time to research on Texas history and to writing popular articles for the *Dallas Morning News*. Dr. Alexander's biography of Hill is scholarly, capable, and a most welcome addition to the history of American geology.

THE PERIGLACIAL ENVIRONMENT, by Hugh M. French. Published by Longman Group Limited, London, and Longman Inc., New York, 1976, x + 309 pp., illus., $20.00

In this work, Dr. French, evaluates the nature of geomorphic processes and landforms in high latitude periglacial environments to provide a guide to recognition and interpretation of periglacial features in glaciated regions of North America and Europe. The book is divided into three sections. In the first, the extent of the periglacial domaine and the variety of periglacial climates are considered. In the second part, there is a systematic treatment of the various geomorphic processes presently operating in periglacial environments. When possible, the relationship between geomorphic features and processes is explained. In part three, Pleistocene periglacial environments are considered. Here, the emphasis is on landforms rather than processes and the interpretation of these forms in terms of our understanding of contemporary periglacial environments and processes. The regional scope and emphasis of the book are correlated with the areas where the author has personal field experience. Thus, the overall treatment is more concerned with lowland rather than alpine periglacial environments. This volume should be of interest to both geographers and geomorphologists.

LANDFORMS AND LANDSCAPES, by Sherwood D. Tuttle. Published by Wm. C. Brown Company, Dubuque, Iowa, 1975, second edition, viii + 152 pp., illus., paperbound.

This volume is intended to introduce geomorphology to nonscience majors. Following the introduction, weathering and mass wasting, stream growth and valley development, stream-eroded landscapes, glaciers and glaciated landscapes, and the effects of wind, waves, ground water, and volcanism are among the subjects treated. A chapter on geomorphic systems, their theory and philosophy, is included.

EUTREPHOCERAS (NAUTILOIDEA) FROM THE PALEOCENE BEAUFORT FORMATION OF NORTH CAROLINA

RICHARD H. BAILEY
NORTHEASTERN UNIVERSITY, BOSTON, MASS.

ABSTRACT

Well preserved specimens of *Eutrephoceras sloani* Reeside, collected from a recently exposed outcrop of the Paleocene Beaufort Formation in east-central North Carolina, represent the first reported Paleocene nautiloids from Coastal Plain strata of North Carolina. This species was formerly known only from the Paleocene Black Mingo Formation in eastern South Carolina, about 280 km southwest of the North Carolina Paleocene outcrops. The North Carolina specimens allow clarification and elaboration of Reeside's original description.

INTRODUCTION

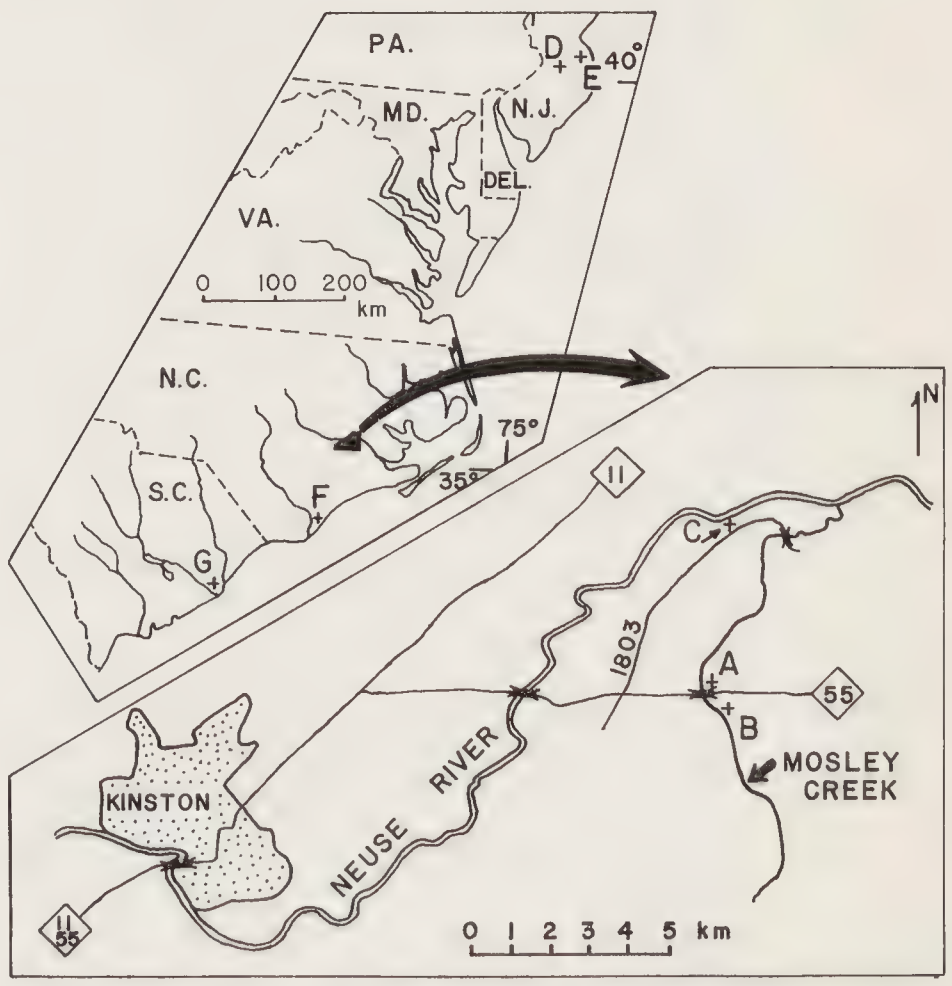
Fossil nautiloids are generally rare in Paleocene strata of the Atlantic Coastal Plain. This scarcity of nautiloid specimens probably results in part from a rather limited area of Paleocene outcrop; however, ecological factors may also be important.

A recently exposed Paleocene outcrop in east-central North Carolina yielded well preserved nautiloid specimens. These nautiloids, identified in this paper as *Eutrephoceras sloani* Reeside, represent the first reported Paleocene cephalopods from North Carolina. The discovery of *E. sloani,* approximately 280 km northeast of the eastern South Carolina outcrop from which it was previously known, allows a significant extension of the geographic range of the species (text fig. 1).

A difficulty encountered in the study of the genus *Eutrephoceras* is that Paleocene and Eocene species from the Atlantic Coastal Plain are represented by few specimens. Little is known of the range of variation of most of the species discussed in this paper. Kummel (1956, p. 379) stated that species in the long ranging *Eutrephoceras* generic group seem to be gradational and generally lack definitive morphological features. The most important diagnostic characteristics for separation of species seem to be conch shape and suture pattern. Specimens of *Eutrephoceras* frequently have been subjected to post-depositional compression, which greatly distorts the conch shape, and complicates the separation of species. Detailed consideration of suture patterns adds objectivity to the rather general comparisons that have been made among species of *Eutrephoceras* in the past. All of the suture patterns (text fig. 5) used for species comparisons were taken from type specimens. Most of these suture patterns have not been illustrated and compared graphically.

STRATIGRAPHY

The new North Carolina outcrop consists of 1.4 m of Paleocene strata which is dis-



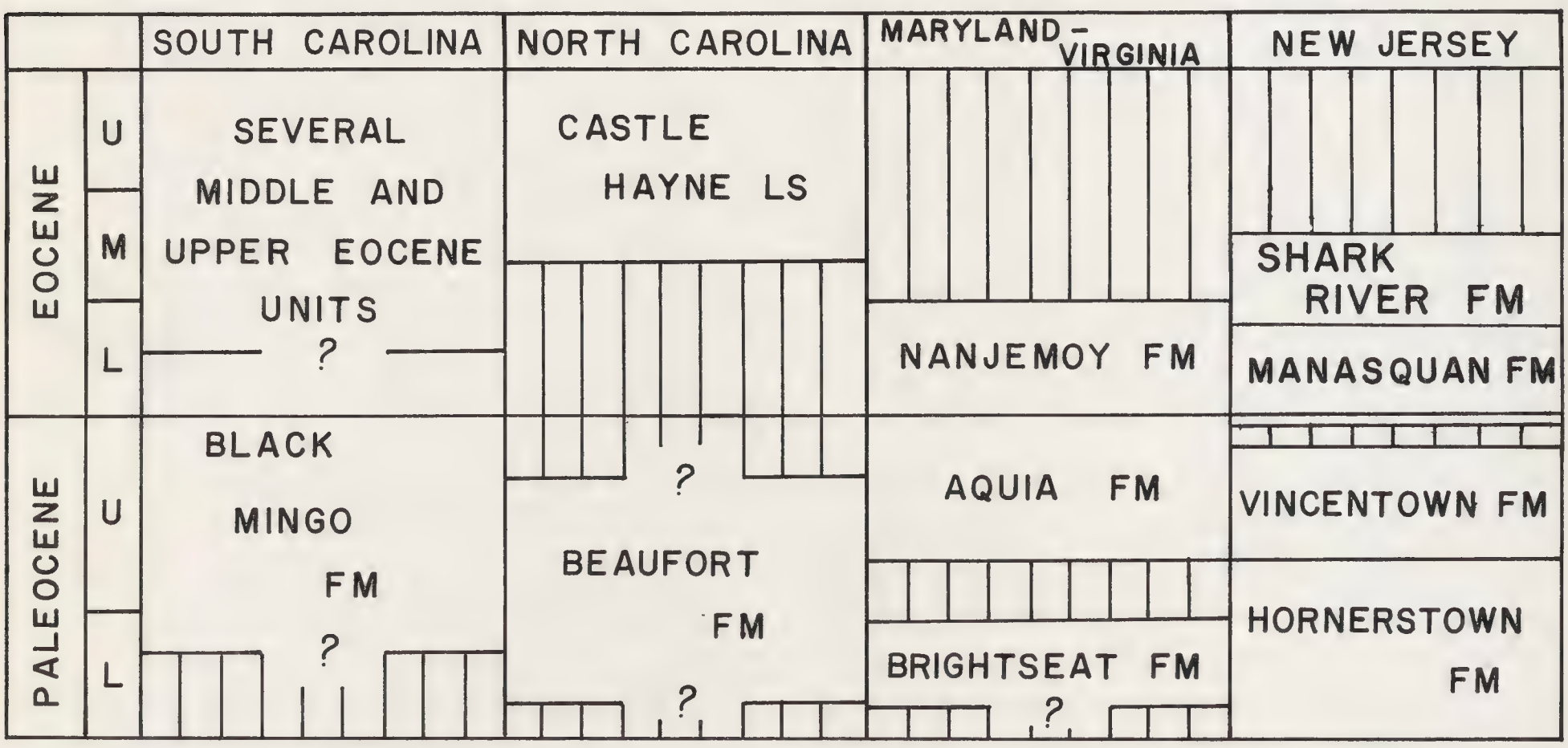
Text fig. 1, Index map showing collection localities for *Eutrephoceras sloani* in North Carolina (A and B, specimens collected *in situ);* locality of the first Paleocene outcrop reported from North Carolina (C); and collection localities of other species discussed in this paper, (D) *E. bryani,* (E) *E. cookanum,* (F) *E. berryi* and *E. carolinensis,* (G) *E. sloani.*

continuously exposed along the banks of Mosley Creek, a northward flowing tributary of the Neuse River. Along portions of the creek, Paleocene rocks are disconformably overlain by about 0.3 m of the Eocene Castle Hayne Limestone (text fig. 3). The Paleocene-Eocene unconformity is marked by a significant lithologic change. Paleocene fossils and clasts of indurated Paleocene sediment have been reworked into the basal Eocene strata, which overlies an undulating erosional surface.

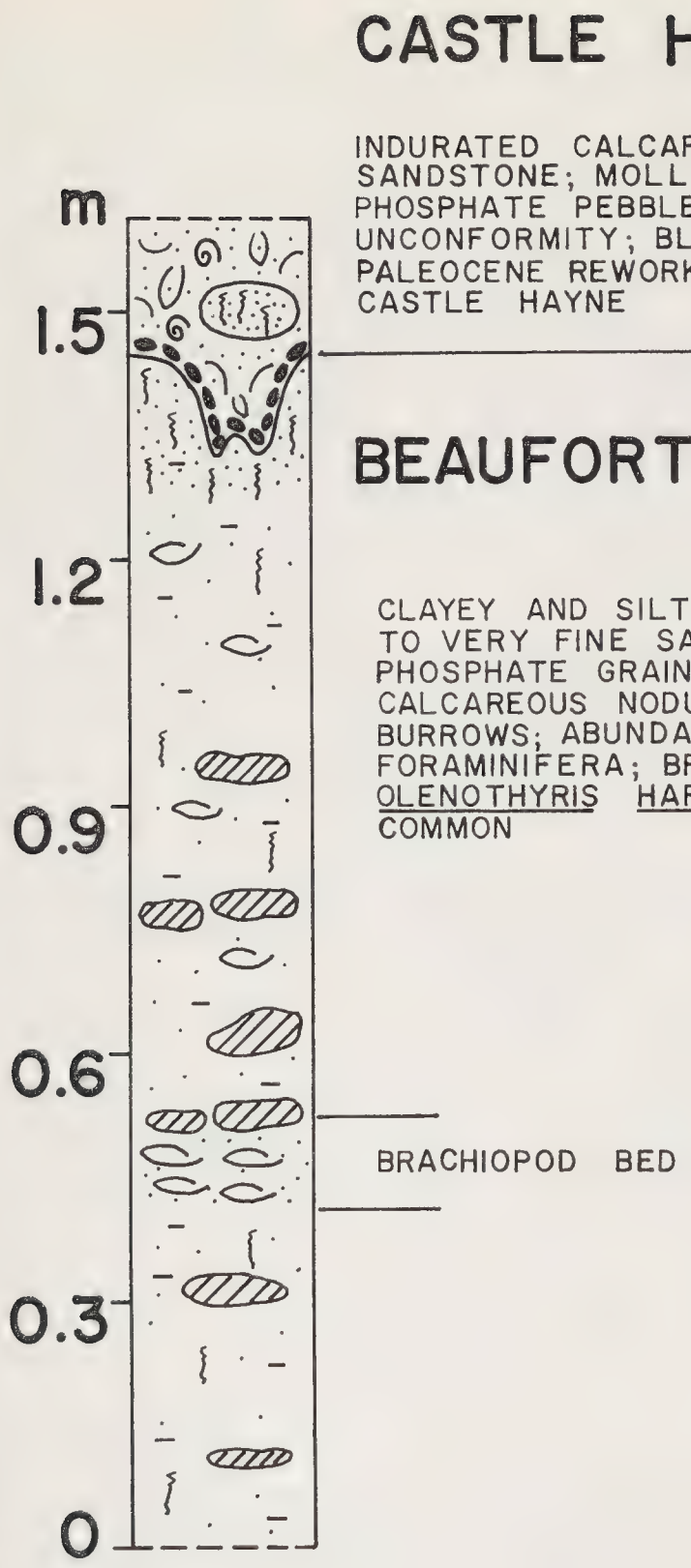
Swift and Heron (1969, p. 229) were the first to record the presence of Paleocene rocks cropping out in North Carolina. Their Danian (lower Paleocene) age was assigned on the basis of planktonic foraminifera collected from an outcrop at West Landing on the Neuse River near the nautiloid locality discussed in this paper (text fig. 1). At the Neuse River outcrop, 1 m of thinly laminated Paleocene shale disconformably overlies 2 m of the Cretaceous Peedee Formation. Extensive exploration along the Neuse River between North Carolina state road 55 and the mouth of Mosley Creek revealed but one significant outcrop, located 3.5 km downriver from West Landing (text fig. 1). This exposure is identical to the section described by Swift and Heron (1969, p. 230) and implies that the Paleocene locality they discussed was inadvertently placed at West Landing. A thorough search of the Neuse River outcrop discussed above yielded no Paleocene macrofossils. Several poorly exposed outcrops of Paleocene shale were found along Mosley Creek, about 0.2 km south of the creek's mouth. No macrofossils were found at these localities.

Brown (1959, p. 8) established a subsurface Paleocene unit, the Beaufort Formation, which has been identified in many wells in east-central North Carolina.

Wilson (1972, p. 129) identified two fossils commonly found in certain Paleocene rocks of New Jersey, the brachiopod *Olenothyris harlani* (Morton) and the bivalve "*Gryphaea vesicularis* (Lamarck)," from the outcrops along Mosley Creek. Wilson suggests that these rocks are probably an extension of the subsurface Beaufort Formation. Swift and Heron (1969, p. 229) assigned the Paleocene shale along the Neuse River to the Black Mingo Formation, a Paleocene-Eocene unit which crops out in South Carolina. Based on the lithologic similarity and the geographic proximity of the subsurface Beaufort Formation to the Paleocene rocks which crop out in east-central North Carolina, it seems logical to apply the name Beaufort Formation to both.



Text fig. 2. Correlations of Paleocene and Eocene units of part of the Atlantic Coastal Plain, modified after Loeblich and Tappan, 1957, p. 177; Hazel, 1968, p. 105; Enright, 1969, p. 17; and Olsson, 1970, p. 591.



Text fig. 3. Composite section of Paleocene strata exposed in the banks of Mosley Creek from 0.2 km north of N.C. Route 55 to 1.8 km south of N.C. 55. Top of section covered by Pleistocene? sands; base of section in creek bed.

Thomas Gibson identified the following species of planktonic foraminifera from the Paleocene rocks along Mosley Creek:

Truncorotataloides (Morozovella) aequa (Cushman and Renz)
T. (Morozovella) apanthesma (Loeblich and Tappan)
T. (Morozovella) angulata (White)
T. (Planorotalites) pusilla (Bolli)
T. (Planorotalites) pseudomenardii (Bolli)
T. (Acarinina) mckennai (White)
Globigerina (Subbotina) triloculinoides Plummer

This assemblage suggests an early late Paleocene age for the exposed Beaufort Formation (Gibson, pers. comm.).

In the Atlantic Coastal Plain, specimens of *Eutrephoceras* have been reported from the Paleocene Vincentown Formation and the middle Eocene Shark River Formation of New Jersey, the Eocene Castle Hayne Limestone of North Carolina, and the Paleocene-Eocene Black Mingo Formation of South Carolina (text fig. 2). Specimens of *Eutrephoceras* have not been reported from the rather well exposed Paleocene strata of Maryland and Virginia.

SYSTEMATIC PALEONTONOGY

Family NAUTILIDAE de Blainville, 1825

Genus EUTREPHOCERAS Hyatt, 1894

Type species: *Eutrephoceras dekayi* Hyatt, 1894

EUTREPHOCERAS SLOANI Reeside

Plate 1, figs. 1-4; Plate 2, figs. 1-4; text figs. 4, 5

Eutrephoceras sloani REESIDE, 1924, p. 1-7, pls. 1-3, text fig. 1.

Material. — Three internal molds; no original shell material; (Pl. 1, figs. 1-3) very slightly deformed conch with 8 camerae; (Pl. 1, fig. 4; Pl. 2, figs. 1-3) adapical portion of conch is severely crushed, adoral portion and living chamber slightly deformed; (Pl. 2, fig. 4) lateral compression has distorted form and suture pattern.

Description. — North Carolina specimens are involute, compressed with a very broadly arched venter and with gently arched, nearly parallel, lateral zones (text fig. 4), leading to an abrupt umbilical shoulder which forms a deeply impressed umbilicus, 12 to 15 mm in diameter. Maximum diameter of largest conch (Pl. 2, fig. 4) is about 150 mm, containing 12 camera to outer volution. Camerae of phragmacone expand rapidly and adoral portion of living chamber is flared. Living chamber, as preserved on two specimens (Pl. 2, figs. 1-4), consists of approximately one-third of the last volution. Siphuncle is holochoanitic, nearly central, perhaps slightly closer to dorsum than venter, and has a maximum diameter of 6 mm (Pl. 1, fig. 1).

External suture consists of a broadly and gently arched ventral saddle, a very gently arched, symmetrical lateral lobe, and a small umbilical saddle (text fig. 5). Internal suture consists of a gently arched dorsal lobe.

Discussion. — The holotype and only known specimen of *E. sloani* is an incomplete internal mold with much of the ventral portion and the adoral half of the last volution missing. The siphuncle, body chamber, and several partial sutures are preserved.

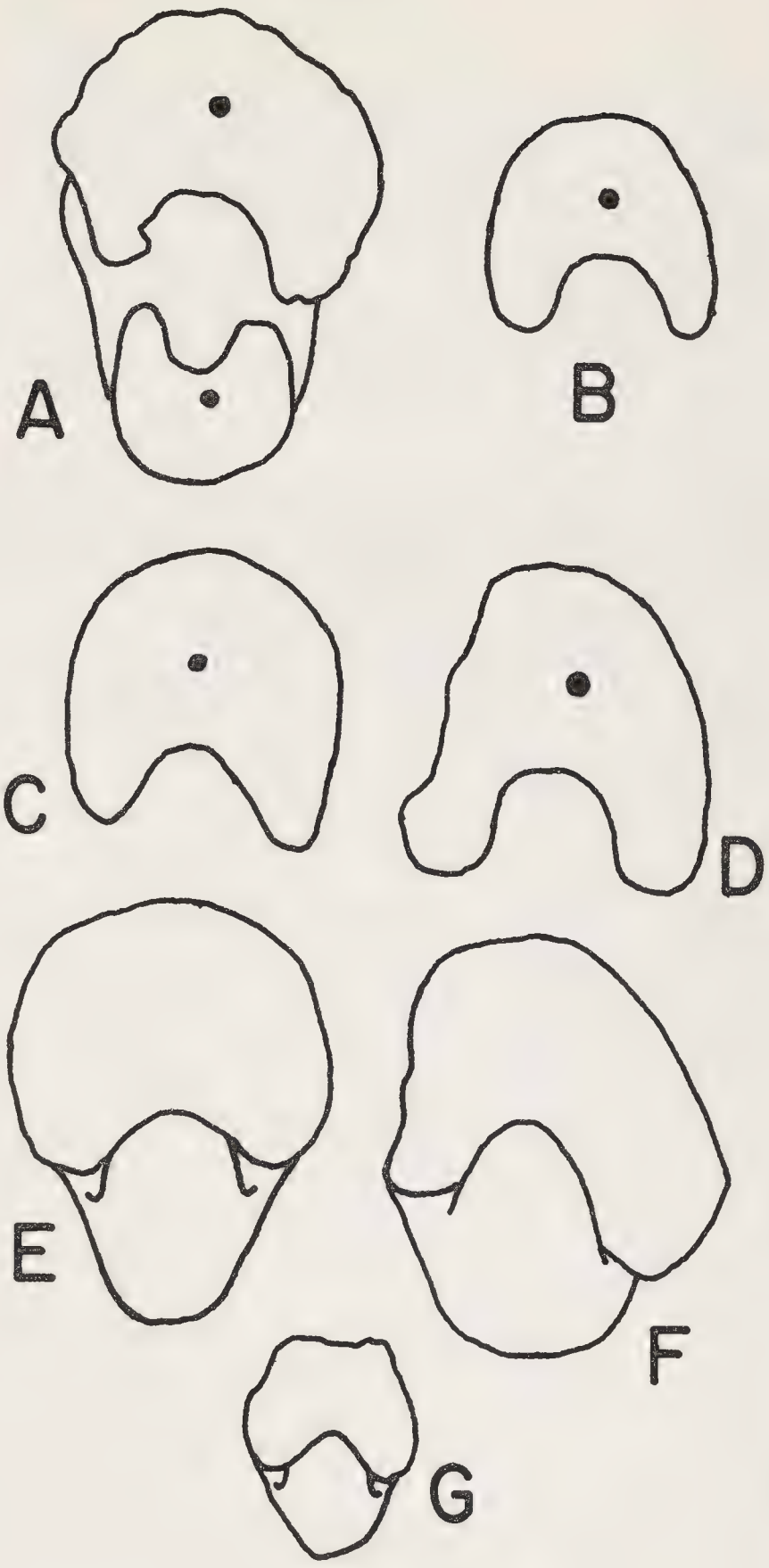
The suture diagrammed by Reeside (1924, p. 3, fig. 1) is atypical of the genus and appears to have been taken from a portion of the holotype that was deformed and eroded. The only intact suture on the holotype is illustrated in text fig. 5. As the holotype is badly deformed, the conch cross-section illustrated by Reeside (1924, p. 3, fig. 1) is difficult to evaluate; however, the cross-section appears to have been roughly equidimensional and very close in shape to the cross-section of the North Carolina specimens (text fig. 4). The external suture of *E. sloani* has a broad ventral saddle and a lateral lobe, similar to the sutures on the North Carolina specimens; however, the suture on the holotype is incomplete. The maximum diameters of *E. sloani* (140 mm) and that of the largest Mosley Creek specimen (150 mm) are similar. It is not known whether either specimen represents a mature individual.

A nearly perfect topotype? of *E. sloani,* listed on an old label in the tray with Reeside's type, unfortunately appears to have been lost. Based on the material I have studied, the similarities of the new specimens to *E. sloani* are great and although the holotype is poor the identification seems justified.

Four other species of *Eutrephoceras* have been found in Paleocene and Eocene formations of the Atlantic Coastal Plain.

The sutures of the North Carolina specimens and those of *E. cookanum* (Whitfield) from the Eocene Shark River Formation of New Jersey are nearly identical (text fig. 5). Reeside (1924, p. 4) stated that *E. cookanum* was broader in cross-section than *E. sloani;* however, the type specimens indicate that just the reverse may be true. (text fig. 4).

E. cookanum attains a large size, nearly 300 mm in diameter, which is much larger than *E. sloani.* Specimens of *E. sloani* (Pl. 2,

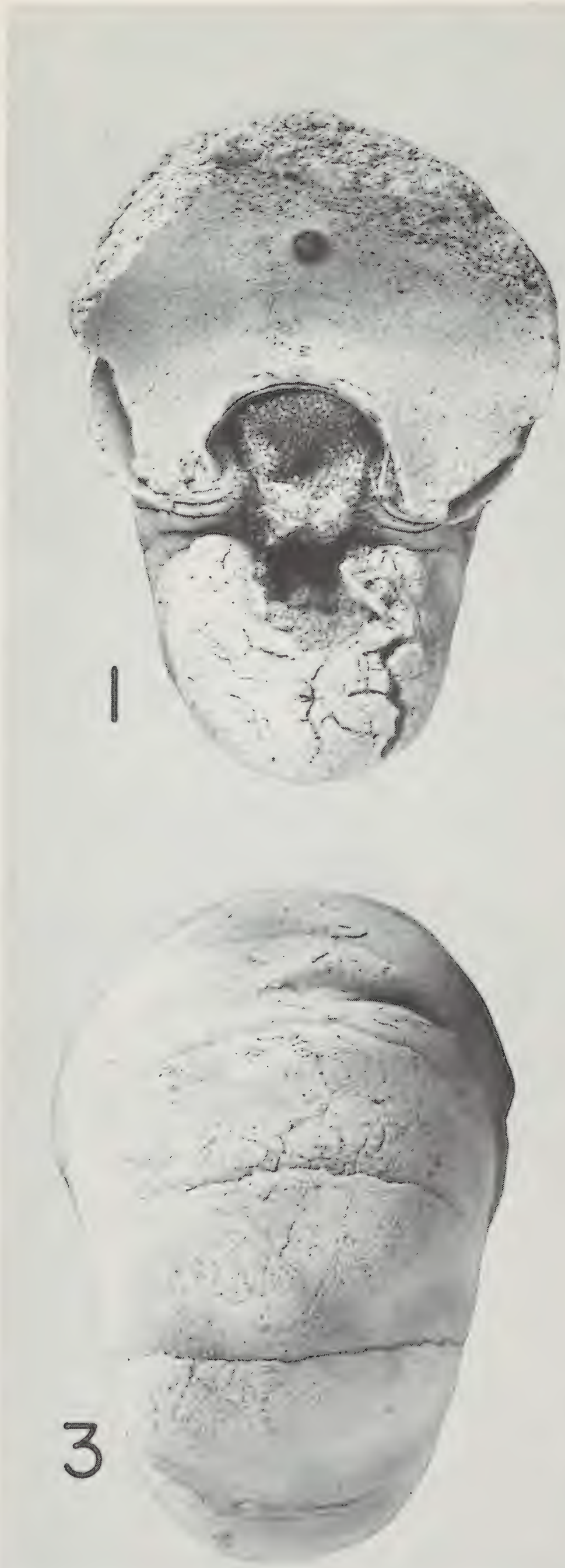


Text fig. 4. Whorl cross-sections of *Eutrephoceras* from the Atlantic Coastal Plain (all X 0.28): (A) *E. sloani,* hypotype USNM 219439, Beaufort Fm., (B) *E. sloani,* hypotype USNM 220133, Beaufort Fm., (C) *E. bryani,* holotype ANSP 16117, Vincentown Fm., (D) *E. cookanum,* after (Whitfield, 1892), Shark River Fm., (E) *E. berryi,* holotype USNM 559584, Castle Hayne Ls., (F) *E. sloani,* holotype USNM 352559, Black Mingo Fm., (G) *E. carolinensis,* after Kellum, 1926 , Castle Hayne Ls.

PLATE 1

Figs. 1-3. *Eutrephoceras sloani* Reeside
Beaufort Formation, Craven Co., North Carolina, USNM 219435, X 0.74

Fig. 4. *Eutrephoceras sloani* Reeside
Beaufort Formation, Craven Co., North Carolina, USNM 220133, X 0.97.



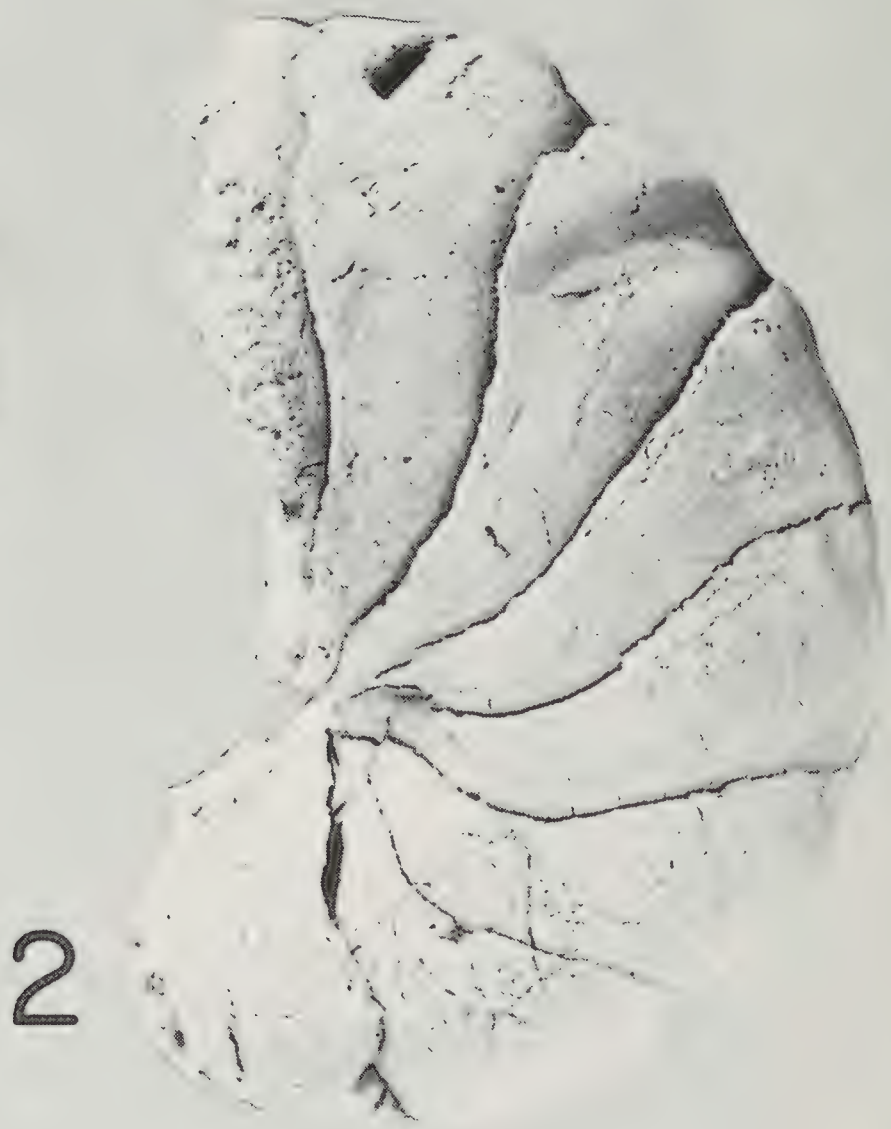


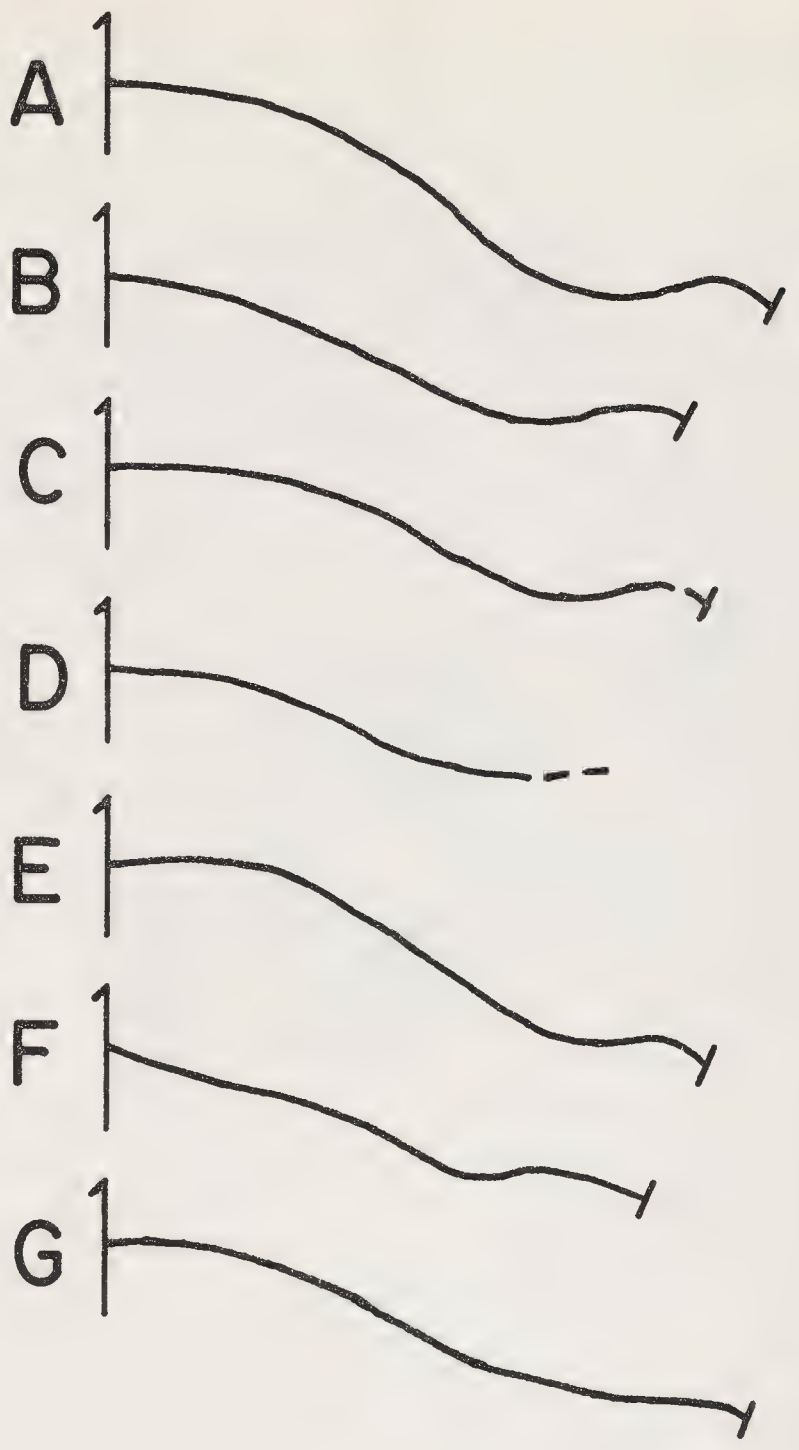
PLATE 1

figs. 1-4) and *E. cookanum* (Pl. 2, figs. 4-6) illustrate the difficulty of separating the species when the conchs have been distorted by compression.

E. bryani (Gabb) occurs in the Paleocene Vincentown Formation of New Jersey (text fig. 2). This species is narrower, expands much less rapidly, and has lateral zones which are more nearly parallel than the North Carolina specimens (text fig. 4). The external suture of *E. bryani* (text fig. 5) is very straight with a small lateral lobe. The internal suture has a small v-shaped annular lobe. Miller (1947, p. 30) stated that *E. cookanum* also has an annular lobe in the center of the dorsal lobe, a feature which is definitely not present on the internal suture of the Mosley Creek specimens. Stenzel (1940, p. 742) questioned the placement of *E. bryani* in the genus *Eutrephoceras* because of the presence of the annular lobe, a characteristic not typical of many species in the genus.

As one specimen (Pl. 2, fig. 4) was collected from the Paleocene-Eocene contact, species of *Eutrephoceras* from the overlying Eocene Castle Hayne Limestone were studied to eliminate the possibility that this specimen was Eocene in age. Two very broad and rounded species, *E. carolinensis* Kellum and *E. berryi* Miller occur in the Castle Hayne Limestone (text fig. 4). *E. berryi* has a broad shallow lateral lobe and a small umbilical saddle and *E. carolinensis,* a much smaller species, has an almost straight suture (text fig. 5). Both species, although of similar shape, possess straighter sutures than the Mosley Creek specimens.

Occurrence. — East bank of Mosley Creek, a northward flowing tributary of the Neuse River, which forms the boundary between Lenoir and Craven Counties; outcrop is



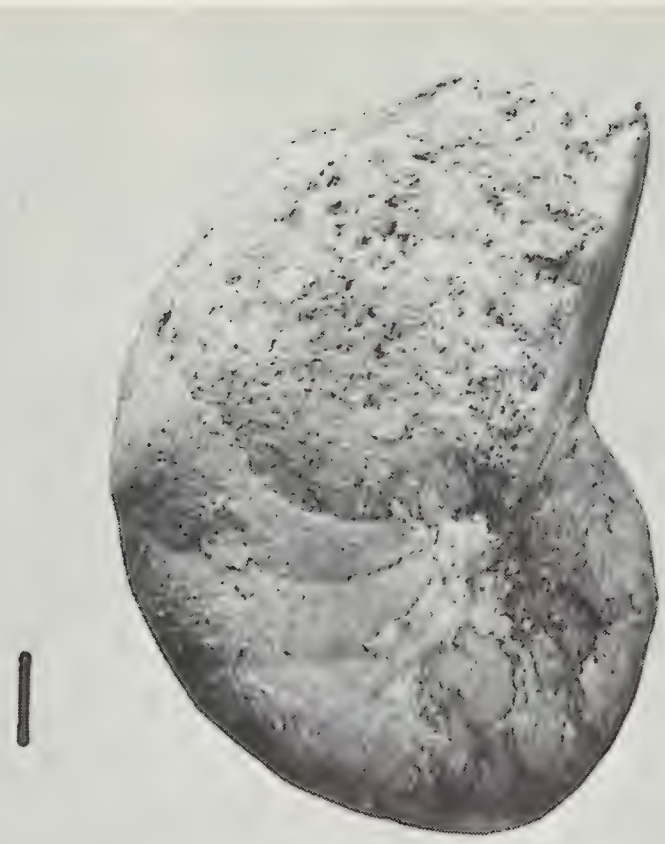
Text fig. 5. Suture patterns of species of *Eutrephoceras* from the Atlantic Coastal Plain (all X 0.63): (A) *E. sloani,* hypotype USNM 220133, Beaufort Fm., at dia. of 100 mm, (B) *E. sloani,* hypotype USNM 220134, Beaufort Fm., at dia. of 90 mm, (C) *E. sloani,* hypotype USNM 219435, Beaufort Fm., at dia. of 80 mm, (D) *E. sloani,* holotype USNM 352559, Black Mingo Fm., partial suture at dia. of about 75 mm, (E) *E. cookanum,* topotype AMNH 9775/2, Shark River Fm., at dia. of 80 mm, (F) *E. bryani,* holotype ANSP 16117, Vincentown Fm., at dia. of 75 mm, (G) *E. berryi,* holotype USNM 559584, Castle Hayne Ls., at dia. of 90 mm.

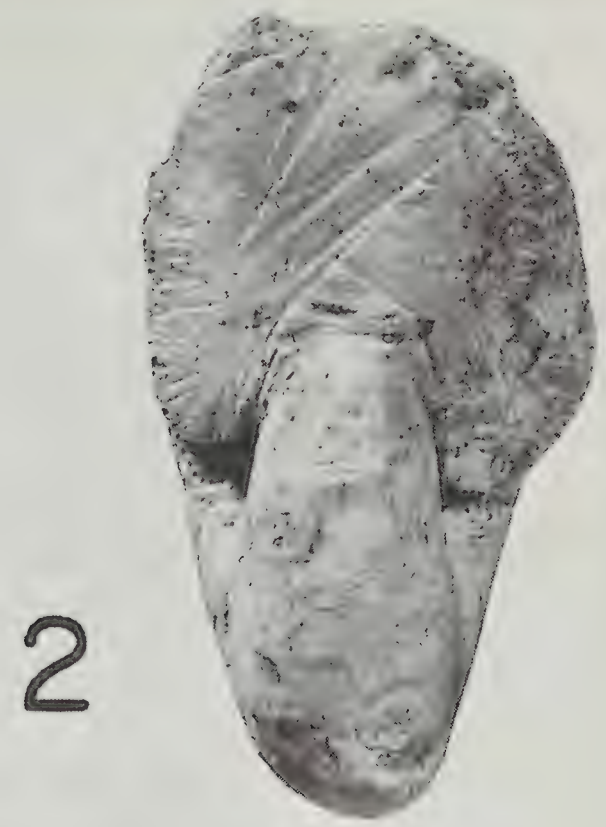
PLATE 2

Figs. 1-3. *Eutrephoceras sloani* Reeside
Beaufort Formation, Craven Co., North Carolina, USNM 220133, X 0.54.

Fig. 4. *Eutrephoceras sloani* Reeside
Beaufort Formation, Craven Co., North Carolina, USNM 220134, X 0.43.

Figs. 5-6. *Eutrephoceras cookanum* (Whitfield)
Shark River Formation, Monmouth Co., New Jersey, AMNH 9775/2, X 0.57.





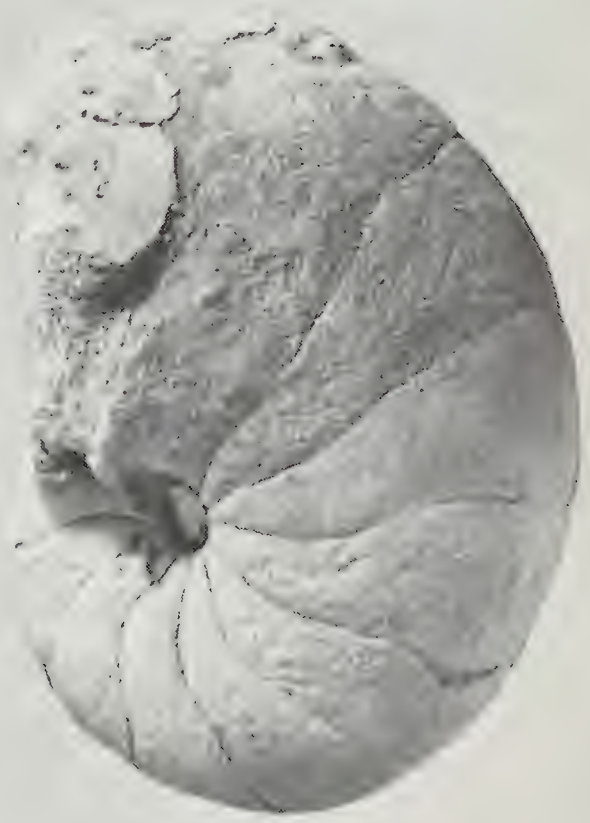


PLATE 2

about 11 km northeast of Kinston, North Carolina. Two specimens collected *in situ;* (Pl. 2, figs. 1-3) about 20 m north of bridge where N.C. Route 55 crosses Mosley Creek, 0.3 m below the top of the outcrop or about 0.6 m below the Paleocene-Eocene contact exposed south of the bridge, collected by R.H. Bailey; (Pl. 2, fig. 4) about 370 m south of bridge, at Paleocene-Eocene contact, collected by D. Wilson, W.C. Blow, R.H. Bailey; (Pl. 1, figs. 1-3) collected from spoil banks adjacent to Mosley Creek by E.C. Womble, south of N.C. Route 55 bridge.

Holotype collected from type section of the Paleocene Black Mingo Formation at Perkins Bluff, west bank of Black River 4.9 km above the mouth of Black Mingo Creek, Georgetown County, South Carolina. Specimen found in silicified and laminated shale about 3 m above the contact with the Cretaceous Peedee Formation.

Types. – Holotype of *E. sloani* is deposited in United States National Museum (USNM 352559). Specimens of *E. sloani* from North Carolina are deposited in the United States National Museum (Pl. 1, figs. 1-3, USNM 219435; Pl. 1. fig. 4, Pl. 2. fig. 1-3, USNM 220133; Pl. 2. fig. 4, USNM 220134).

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I thank Warren C. Blow of the U.S. Geological Survey for his companionship in the field and for many helpful suggestions. Druid Wilson, U.S. Geological Survey, loaned a nautiloid specimen and guided the initial interest which led to his discovery of the Paleocene age of the Mosley Creek outcrop.

Horace G. Richards, Philadelphia Academy of Sciences; Norman D. Newell, American Museum of Natural History; and Thomas R. Waller, U.S. National Museum loaned essential type specimens. Albert E. Sanders of the Charleston Museum made a thorough, but unsuccessful, search for a reported, more complete topotype of *Eutrephoceras sloani.* I am indebted to P.J. Harmatuk who loaned several nautiloid specimens and to E.A. Womble, who loaned an excellent specimen of *E. sloani* from Mosley Creek. Clayton E. Ray, of the U.S. National Museum, was of great assistance in obtaining the specimens collected by Womble and Harmatuk.

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December 29, 1976

CHARLES LYELL IN LOUISIANA

HUBERT C. SKINNER
TULANE UNIVERSITY

In 1845-1846, Charles Lyell, renowned British geologist and author of the *Principles of Geology* (London, 1830-1833, et seq. ed.), made a second visit to the United States of America, a geological excursion during which he came to Louisiana to view and study the Mississippi River and its delta. The intent here is to review Lyell's observations on the lower Mississippi River and other geological features in Louisiana and briefly to evaluate his influence on subsequent studies. He was the first qualified earth scientist to visit and comment on the Louisiana area.

Charles Lyell and his wife reached the City of New Orleans on the 24th of February 1846, during his second visit to the United States.[1] He had travelled the distance of 175 miles by coastwise steamer through the "inland passage", a natural channel positioned between the mainland and a series of offshore bars which lie a few miles off the coast and serve to shield the states adjoining the northeastern Gulf of Mexico from the turbulence of the open Gulf waters. The route then led through a deep, narrow inlet or pass into Lake Pontchartrain and along its southern shore to a landing six miles north of the city. At this point, the Lyells disembarked and continued their journey by rail, for the short remaining distance into New Orleans.

By the time Mr. Lyell reached New Orleans, his reputation as a geologist was established firmly. He was quite well known to local scientists, and to many others among the citizenry. In the pages of the *Daily Picayune,*[2] he was referred to as "Mr. Lyell, the celebrated geologist." Among those he met with at New Orleans, were two of the most distinguished men of science in Louisiana, William Marbery Carpenter, first Dean of the Louisiana School of Medicine, and John Leonard Riddell, inventor of the stereoscopic microscope and professor of chemistry at the University of Louisiana.

Dr. Carpenter, a medical doctor who had an excellent knowledge of and consuming amateur interest in botany and geology, accompanied Mr. Lyell on an excursion down the Mississippi River to its mouths and on another to Lake Pontchartrain, travelling along the *Gnathodon*[3] shell road and returning by boat on Bayou St. John's which still extends today from the lakefront to the old city limits. Also, Dr. Carpenter had published in 1838 an account[4] on Bartram's "fossil forest" at Port Hudson (located on the Mississippi River above Baton Rouge), and he was anxious for his famous visitor to examine this section and to render his geological opinion on the locality. Mr. Lyell later did so, though his view of the cliffs was obstructed seriously by high water.

Dr. Riddell, professor of chemistry at what is now Tulane University, and a most remarkable man, was possessed of many talents and varied interests. He is remembered as a physician who contributed research papers on the yellow fever epidemics, as a botanist interested in the floras of the southern states, and as a geological observer who calculated through experiments the proportion of sediment contained in the waters transported by the Mississippi River, as well as a teacher and a chemist. In 1851, he invented the stereoscopic or binocular microscope, built a working model of this instrument in 1852, and displayed his innovation before the American Association for the Advancement of Science in July 1853.[5] Also, Dr. Riddell was appointed melter and refiner at the New Orleans Mint, and, in August 1860, was appointed postmaster of New Orleans by President Buchanan. He was a man of many facets. Charles Lyell utilized the observations communicated to him by Carpenter and Riddell, and Riddell's experimentally derived figures on the amounts of sediments contained in Mississippi River waters as a basis for his estimates of the antiquity of the lower delta of this great river.

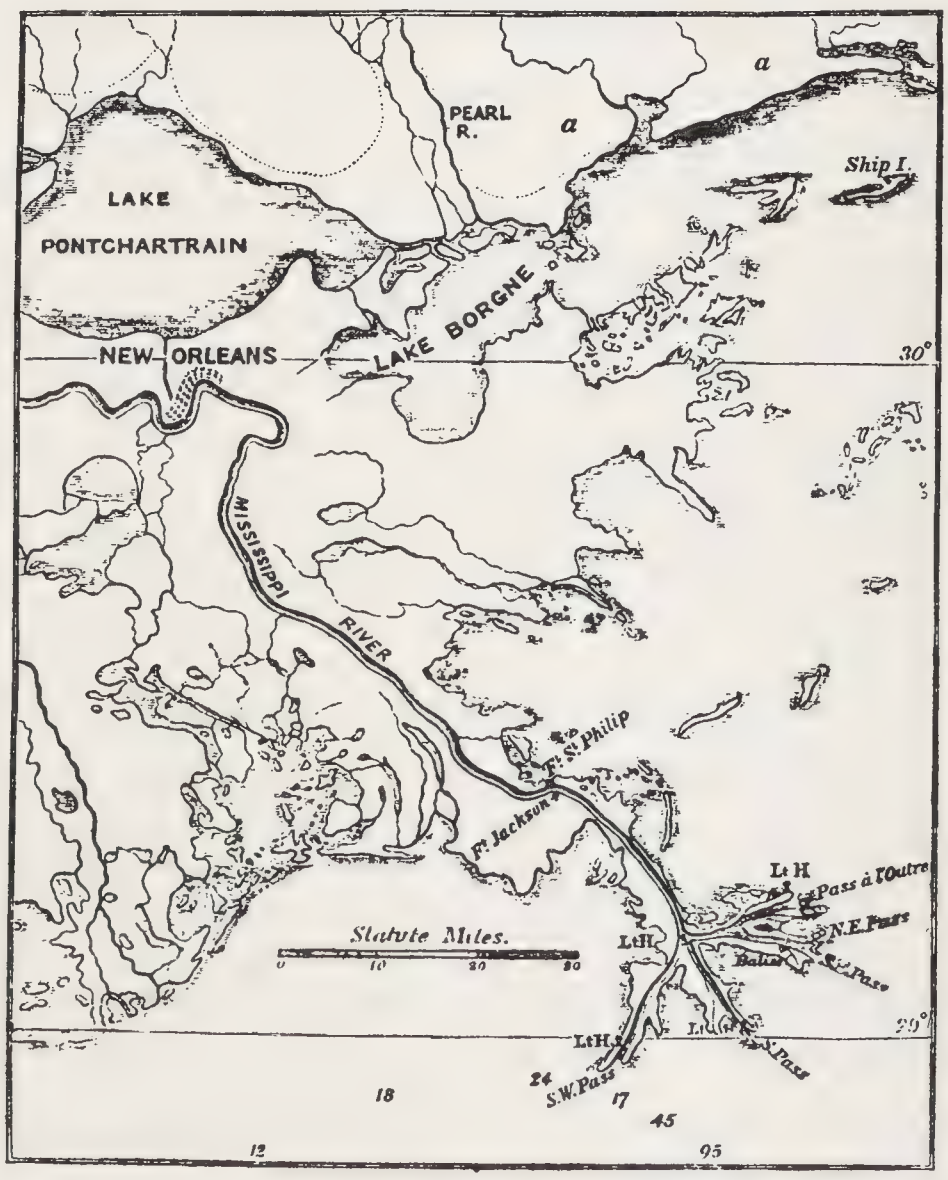
One of Charles Lyell's most significant observations was made as he entered Louisiana before he reached New Orleans, as follows: "We had already entered the large lagoon, called Lake Pontchartrain."[6] In this short, perceptive, and brilliantly-turned phrase, he both labelled the lake correctly and explained its origin. It is, in fact, a shallow land-locked bay or lagoon isolated from the remainder of Mississippi sound by the prograding delta building seaward across an offshore bar. Even today, the origin of Lake Pontchartrain is misunderstood and disputed by many observers who should not have this difficulty. This writer has encountered this problem repeatedly in his own work on the geology of southern Louisiana. For example Lake Pontchartrain has been termed the "world's largest estuary" simply because of the estuarine conditions which are present in the ecosystem of the delta region. Environmentalists and others working on this area today would profit from some measure of the clear insight and understanding demonstrated by Sir Charles in his initial observations.

While in New Orleans, Mr. Lyell inspected some "mammoth fossils" which had been brought into the city from Texas. These bones were to be shipped to England.[7] He found among them fragments of the bones of six different extinct species of fossil quadrupeds. On April 27, he wrote to Leonard Horner from Philadelphia about this, stating: "Tell Dr. Falconer to look out for some splendid teeth of Texas elephants which are going from New Orleans to London for sale."[8] During his brief stay, Charles Lyell sketched the "fine date-palm, thirty feet high, growing in the open air"[9] planted some seventy or eighty years earlier by Père Antoine, a Roman Catholic priest, about whom several romantic tales have been recounted (see Figure 1). Lyell's notice and comments about the venerable date-palm and its cultivator are doubtless responsible for the survival of at least one of the Père Antoine legends. He has been widely quoted by New Orleans writers in the present century[10] and even today he is frequently quoted (or mis-quoted) in the guidebooks prepared for tourists.

During his sojourn in southern Louisiana, Charles Lyell journeyed downriver to Head of Passes where the river waters divide into five channels or distributaries, and beyond to the Balize, the pilot-station then situated near the mouth of Southeast Pass (see Figure 2). On this excursion, he again was accompanied by Dr. William M. Carpenter whose "knowledge of botany and geology, as well as his amiable manners, made him a most

Père Antoine's Date-palm (Phœnix dactylifera).

Figure 1 (from Lyell, 1850, v. II, p. 138)

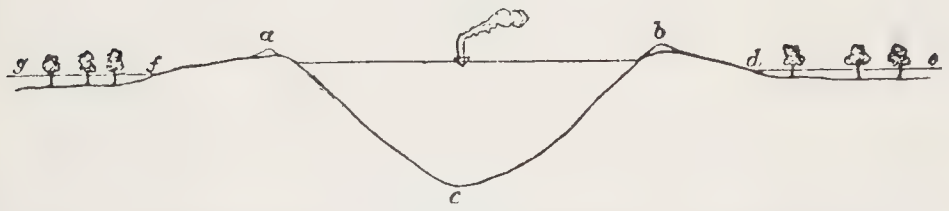


Map of part of the delta of the Mississippi below New Orleans.*

a, a. Post-Pliocene formation, partly marine and partly of cypress-swamp origin, called by Prof. Hilgard 'Coast-Pliocene.'

Figure 2 (from Lyell, 1872, v. I, p. 444)

useful and agreeable companion."[11] On the 110 mile trip, he had an opportunity to observe the natural levees of the river which then extended only 20 miles below English Turn. He commented on the nature and origin of the "narrow banks, protruded for so many miles into the Gulf of Mexico" with no bluffs present on either bank of that "powerful body of fresh water flowing in a valley more than a hundred feet deep, with vast mounds of mud and sand on each side."[12] (see Figure 3) He was intrigued by



Section of channel, bank, levees (*a* and *b*), and swamps of Mississippi River.

Figure 3 (from Lyell, 1850, v. II, p. 170)

the relative stability of the banks and bayous or channels as demonstrated by comparison of the terrane he saw with Charlevoix's maps of 1834.[13] His observations failed to yield the evidence he had hoped to find which would enable him to calculate the rate of advance of the delta. However, he did surmise from the reported rates of change in the mud and sand bars restricting main channels during times of reduced flow, that several thousand years would be required for the river to advance from New Orleans to the Balize. Later, using data on the transported solids in Mississippi River waters provided from his experiments by Dr. Riddell and, assuming that the delta had a thickness of 528 feet or one-tenth mile, Mr. Lyell calculated that the 13,600 square miles of delta must have taken about 67,000 years to form. An article on these observations was published later in 1846.[14] Recent research based on modern technology indicates that this calculation is too high by one order of magnitude, but the variables and possible errors in his calculations enumerated by Mr. Lyell can easily account for this difference.

On March 10, the Lyells left New Orleans and began to ascend the river. Mr. Lyell had made arrangements to land at Port Hudson to examine the "fossil forest" in the bluffs there, and Mrs. Lyell went directly to Natchez where he was to join her a few days later. As he travelled up the river, Mr. Lyell had the opportunity to examine what remained of the "entrance of what is called the Cartharge crevasse," a large break opened in the levee by floodwaters in May 1840, and causing the river to discharge its floodwaters eastward into that "great lagoon" Lake Pontchartrain for a period of eight weeks.[15] Near Bayou Sara he viewed a similar break in the levee from the great flood of 1844. He also saw much additional evidence of the effects of cut-and-fill action on the banks of the dynamic river, and was able to view the horse-shoe shaped oxbow lakes such as Lake Solitude and Fausse Rivière, left behind by the meandering river. Above St. Francisville, they passed the Raccourci Cutoff, a trench nine feet deep dug as an attempt to shorten the navigation channel by 25 miles.[16] The flood waters of 1845 had rushed through the cut with great velocity but had failed to open the new channel. Only two years after Mr. Lyell was there, in 1848, the Raccourci Cutoff opened and today Raccourci Old River is another oxbow lake.

At Port Hudson, Charles Lyell disembarked to examine the geology of the bluffs containing the "fossil forest" described to him by Dr. Carpenter. Unfortunately, the bed of buried stumps was 12 feet under water and the "fossil forest" could not be seen. However, Mr. Lyell was able to find similar though not so ancient buried stumps of cypress trees at higher levels nearby. From his observations he was able to conclude that significant changes in the relative levels of land and sea had taken place, and to estimate the magnitude of this change at 150 feet.[17]

At Natchez, great bluffs of loess stand 200 feet above the river for a distance of several miles. Mr. Lyell noted the resemblance of these deposits to "loess" or "fluviatile silt" in the valley of the Rhine River and commented on the shells of land-snails contained within both "loams" and on the similarity of their lateral passage into lacustrine deposits.[18] He visited the "Mammoth ravine" nearby which was named for the numerous fossils of Pleistocene quadru-

peds recovered there. He suggested, however, that the fragment of human pelvis shown to him was intrusive and had been washed out of "some old Indian grave" farther upstream.[19] He viewed recent landslips on the bluffs and was able to estimate the rate of eastward migration of the river.

At Vicksburg, great bluffs rise above the river similar to those at Natchez, but here beneath the "freshwater loam", Charles Lyell recognized "a marine tertiary deposit, of the Eocene period, in which we collected many shells and corals."[20] (see Figure 4) He

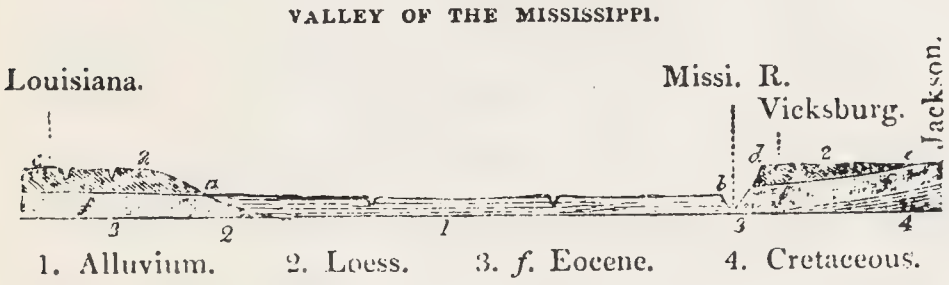


Figure 4 (from Lyell, 1850, v. II, p. 257)

made a trip overland by railroad to Jackson during which he recognized both the "loam" of the Pleistocene terraces and the Eocene strata rising to the surface farther east. From Vicksburg, the Lyells resumed their journey up the river and left the Louisiana area, reaching Memphis on 24 March 1846.[21]

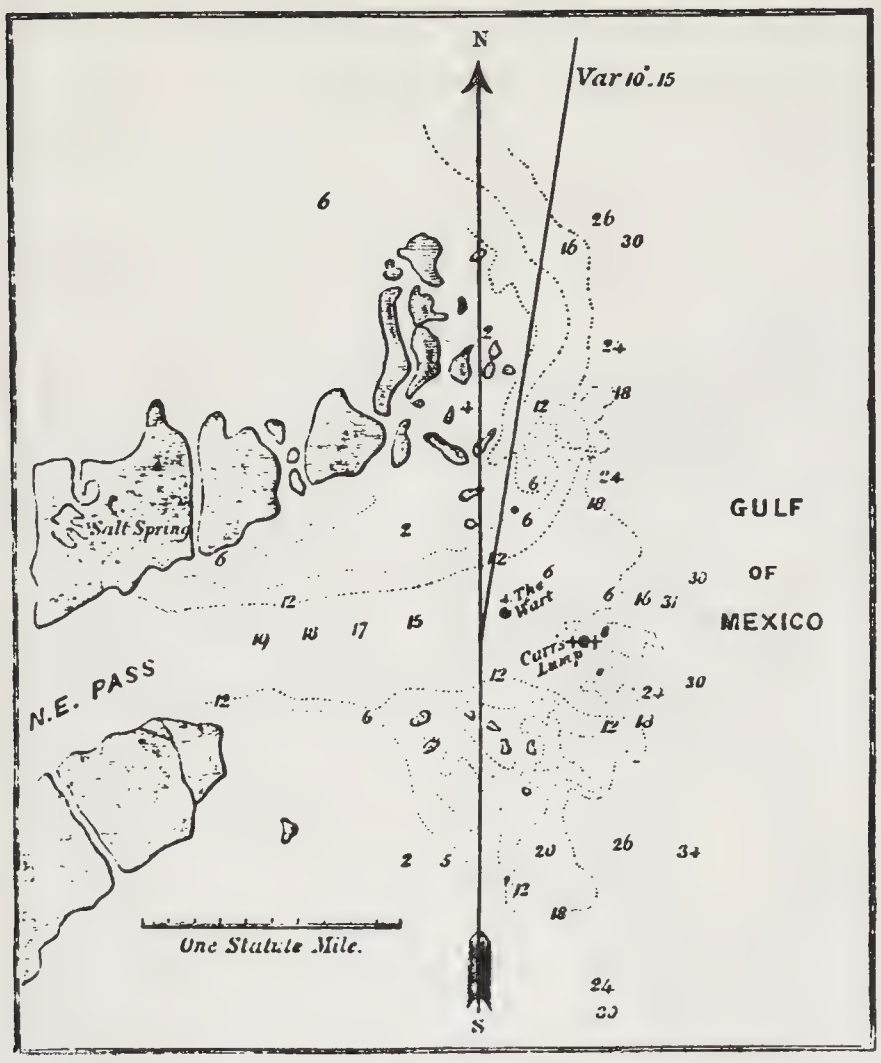
Charles Lyell has been quoted extensively by subsequent writers on Louisiana Geology. The first of these, Marie-Joseph Raymond Thomassy, a French hydraulic engineer, visited New Orleans in 1858-60 and became fascinated with the Mississippi River and the coastal plain of Louisiana. His intense interest and scientific curiosity led him to write the pioneer work on Louisiana geology *Géologie Pratique de La Louisiane,* published in New Orleans in 1860. Near this time, a Creole gentleman overheard some intemperate remarks by Thomassy about the size of the Mississippi River compared to the rivers of France. He was challenged by the Creole, and was forced to fight a duel over the size of the Mississippi River. Thomassy lost the duel but survived with only a painful disfiguring injury to remind him of the incident. He lost, by his own account, because of the "miserable character of your American steel."[22] This event may help to explain his rather strongly critical treatment of Lyell's observations. In the foreword of his *Practical Geology of Louisiana.* He took Sir Charles to task, as follows (in translation): "Through a mistake, or an oversight equally regrettable, that celebrated geologist did not bring out the part played by *mud springs* and *mud lumps,* springs and mounds of mud, which emerge from the waves of the Gulf of Mexico, sometime even in the middle of the passes of the river, revealing the presence of a new active agent in the progressive formation of the delta."[23] (see Figure 5) Four

S. View of Carr's Lump, N.E. Pass.
Extreme height above low water, 8 feet.

Figure 5 (from Lyell, 1872, v. I, p. 446)

times, Thomassy criticizes grave errors of omission, "all the more regrettable on the part of so eminent a mind."[24] It should be recorded that the subject of mud lumps in the passes of the Mississippi River is treated fully in later editions of the *Principles of Geology.* (see Figure 6) Later authors, such as Hilgard (1873) and Harris and Veatch (1899), treated Charles Lyell more kindly and fairly. They chose to comment on his actual observations rather than his apparent omissions.

In summary, the visit of Charles Lyell to Louisiana in 1846 was productive and yielded significant results. Especially noteworthy are his comments on the extended banks of the Mississippi River at its mouths, the nature of and origin of Lake Pontchartrain and Fausse Rivière, his descriptions of the exposed Tertiary strata and the overlying loess deposits in the bluffs near Vicksburg, his views on the "fossil forest" in the bluffs at Port Hudson, and his discussions of the evidences for subsidence and the probable rates of this subsidence in both the Port Hudson area and in the lower deltaic plain of



Map showing the positions of the Wart and Carr's Mud-lumps at the North-east Pass of the Mississippi River, from a survey of Capt. Talcott, in 1839.*

Figure 6 (from Lyell, 1872, v. I, p. 445)

the Mississippi River. These calculations and his estimates of the age of the river delta based on its calculated mass volume and Riddell's estimates of annual amounts of river transported solid matter, were quite influential at a time when such matters were poorly understood and controversial. Overall, his observations on the Mississippi River and on other geological features in southern Louisiana were most astute and exerted a strong influence on contemporary and later writers on Louisiana geology. Even today, Charles Lyell is quoted frequently and he continues to exercise a significant influence on the geology of Louisiana.

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Volume 13

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Editor

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Associate Editor

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New Orleans

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY is devoted primarily to the geology and paleontology of the coasts and adjacent land areas of the Gulf of Mexico and the Caribbean Sea. Each number contains an individual monographic study, or several minor studies. As volumes are completed, title pages and tables of contents will be distributed to subscribers and institutions exchanging the entire series.

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Deborah S. Vial, *Exchange Director*

Tulane Studies in Geology and Paleontology
Earth Sciences Department
Tulane University
New Orleans, Louisiana 70118
U.S.A.

CONTENTS

VOLUME 13

Number Page

1, 2. SPECIAL PAPERS ON THE HISTORY OF SCIENCE – I: JOHN LEONARD RIDDELL
Karlem Riess 1

3. PRELIMINARY SURVEY OF MODERN MARINE ENVIRONMENTS OF SAN ANDRES ISLAND, COLOMBIA
M. John Kocurko 111

PLIOCENE *VOORTHUYSENIELLA* (PROBLEMATICA) FROM THE TEXAS CONTINENTAL SHELF
Drew Haman 135

COMMENTS ON THE GENUS *VIRGULINELLA* CUSHMAN, 1932 (FORAMINIFERIDA)
Drew Haman 140

4. CARDIIDAE (MOLLUSCA:BIVALVIA) FROM THE CHIPOLA FORMATION, CALHOUN COUNTY, FLORIDA
Harold E. Vokes 143

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION – XXI
A NEW SPECIES OF THE GENUS *LOPHA* (MOLLUSCA: BIVALVIA)
Harold E. Vokes 190

A SECOND WESTERN ATLANTIC SPECIES OF *VITULARIA* (MOLLUSCA: GASTROPODA)
Emily H. Vokes 192

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION – XXII
ON THE OCCURRENCE OF *DOLICHOLATIRUS* (MOLLUSCA: GASTROPODA)
Emily H. Vokes 195

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Volume 13, Numbers 1, 2 September 1, 1977

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JOHN LEONARD RIDDELL

KARLEM RIESS
TULANE UNIVERSITY

p. 1

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Tulane Studies in Geology and Paleontology
Earth Sciences Department
Tulane University
New Orleans, Louisiana 70118
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SPECIAL PAPERS ON THE HISTORY OF SCIENCE – I

JOHN LEONARD RIDDELL

September 1, 1977

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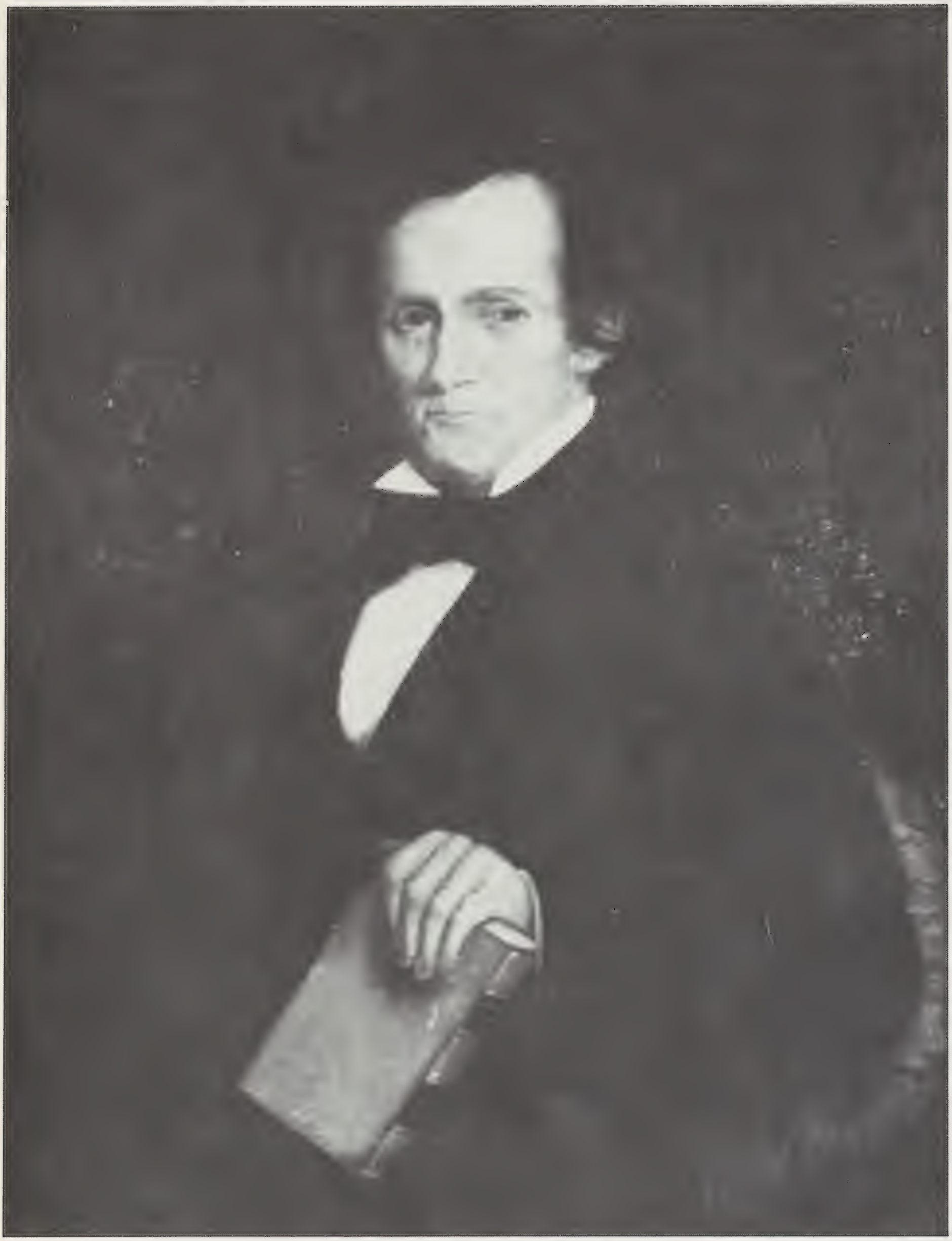


John L Riddell.

1807-1865

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

SPECIAL PAPERS ON THE HISTORY OF SCIENCE – I

JOHN LEONARD RIDDELL

KARLEM RIESS
TULANE UNIVERSITY

CONTENTS

Page

I. INTRODUCTION 2
II. FAMILY HISTORY 4
III. PERSONAL CHARACTERISTICS 6
IV. EARLY LECTURES – OGDENSBURG AND BROCKVILLE – 1830-1831 8
V. WANDERINGS – 1831-1832 11
VI. MARIETTA – 1832 13
VII. WORTHINGTON – 1832-1834 16
VIII. THE BENNETT INCIDENT – 1832-1834 18
IX. CINCINNATI – 1834-1836 19
X. NEW ORLEANS – 1836-1840 28
XI. THE NEW ORLEANS BRANCH MINT – 1839-1848 32
XII. NEW ORLEANS – 1840-1846 36
XIII. SCIENTIFIC ACHIEVEMENTS – 1839-1850 39
Phosphorescent Taper
Pocket Compass
Typewriter
Fishrod Balance
Views on the Constitution of Matter
The Ely-Riddell Controversy
The Riddellian Philosophy
Aerial Navigation
Mathematics and Mechanics
XIV. NEW ORLEANS – 1846-1850 50
XV. NEW ORLEANS – 1850-1860 51
XVI. SCIENTIFIC ACHIEVEMENTS – 1850-1855 55
The Binocular Microscope
"Plants of Louisiana"
Molecular Forces
Medicine – General
Miasm and Contagion-Animalculae-Infectious Diseases
XVII. THE POST OFFICE AT NEW ORLEANS – 1860-1863 70
XVIII. POLITICS – 1863-1865 75
XIX. APPENDIX: THE RIDDELL MINT CORRESPONDENCE 82
XX. BIBLIOGRAPHY 104
John Leonard Riddell – Publications
John Leonard Riddell – Diaries
Reviews of Riddell Publications
Questionable Publications
Publications about Riddell
The Riddell Mint Correspondence

ILLUSTRATIONS

Frontispiece: John Leonard Riddell, 1807-1865 ii
Figure 1. John Leonard Riddell, circa 1855 3
Figure 2. Page from one of Riddell's *Personal Journals* 7
Figure 3. Drawing of Riddell's modification of the barometer 9
Figure 4. Riddell's illustration of "phyllographic printing" 30
Figure 5. Title page of Orrin Lindsay's *Plan of Aerial Navigation* 46
Figure 6. Side view of Riddell's binocular microscope 55
Figure 7. Back view of Riddell's binocular microscope 56
Figure 8. Diagram of Riddell's binocular microscope 56
Figure 9. Arrangement of prisms in Riddell's binocular microscope 57
Figure 10. Riddell's binocular microscope 58
Figure 11. Microscopic observations, engraved on stone by Riddell 64
Figure 12. Microscopic observations, engraved on stone by Riddell 65
Figure 13. Riddell's two cent Postmaster's Provisional Stamp 71
Figure 14. Riddell's five cent Postmaster's Provisional Stamp 71
Figure 15. Riddell's "stamp money", one cent denomination 71
Figure 16. Riddell's handstamped five cent Postmaster's Provisional Envelope 72
Figure 17. Riddell's original tomb in the Protestant Cemetery 81
Figure 18. Riddell's final resting place in Metairie Cemetery 81

I. INTRODUCTION

It is rare that a man combines careers in science and politics. It is more unusual when his scientific achievements cover five distinct fields – medicine, botany, chemistry, geology and physics. John Leonard Riddell was such an unique individual and his place as a leader in science in the deep South during the nineteenth century has been firmly established.

It is doubtful, however, that Riddell will ever be accorded his proper place in the scientific annals of the United States. His work, basic and important, has been superseded by modern refinements and techniques and his publications, although numerous, were confined to a few journals.

Riddell's colorful life, with his passion for all things scientific as its dominant influence, serves as an excellent example of a type non-existent today. In this era of specialization our scientists do not possess the breadth of interest which Riddell and his contemporaries displayed. Nor do we find that adventurous spirit, that eagerness to participate in local cultural, business, and social activities. Few scientists today enjoy the financial success Riddell did.

It is to be regretted that there are no records of his personal life during his most productive years. We would like to know how he became interested in politics, what some of his views were on the major national issues of the time, and how these were developed.

The New Orleans Academy of Sciences, founded by Riddell and others in 1853, remains today a symbol of Riddell's leadership and industry. During his years as president of the Academy, Riddell made the community conscious of the need for such an organization, and laid a firm foundation for its growth and development. Perhaps the community was ready for such an organization, but the driving force was Riddell.

The versatility of John Leonard Riddell – scientist, educator, politician, business man and devoted family man – remains a challenge to young scientists today.

In preparing this manuscript the author has had access to the diaries of John Leonard Riddell, on deposit in the Howard-Tilton Memorial Library, Tulane University, New Orleans, Louisiana. Permission to use these diaries was granted by their owner, Mrs. Jefferson Davis Riddell. They have been

Figure 1. John Leonard Riddell, circa 1855 (courtesy, Rudolph Matas Medical Library, Tulane University).

an invaluable source of details which have been used to supplement the meager biographical sketches which have been published. Permission to reproduce certain illustrations was granted by the Louisiana State Museum (frontispiece), the Rudolph Matas Medical Library of Tulane University, the United States Army Medical Museum, and the New York Public Library.

II. FAMILY HISTORY

The Riddells traced their family ancestry from the Barony of Riddell and Lilerclive in Scotland in the Eighth Century. Robert Riddell, great-grandfather of John Leonard Riddell, was born in Coleraine, Londonderry County, Northern Ireland in 1713, and emigrated to New England in 1737. Robert married Mary Thompson, and their son Gawn was born in Londonderry, New Hampshire on February 22, 1753. Gawn married Margaret Taggart, also of Londonderry. John, the son of Gawn and Margaret, was born in Colerain, Massachusetts, December 15, 1783. John was educated at Deerfield Academy, and became a school teacher, constable, justice of the peace, and a captain of militia. He was tall and slim, with light blue eyes and dark hair.

John married Lephe Gates of Leyden, Massachusetts, the daughter of Peter and Mary (Molly) Allen Gates. The young couple was living with the Gates family in Leyden at the time John Leonard Riddell was born, on February 20, 1807. John Leonard was the first of a family of ten children. Family records tell us that Lephe Riddell was dangerously ill for some months following John Leonard's birth, forcing the family to remain in Leyden until she was completely well. John and Lephe then moved to the paternal homestead in Colerain, Massachusetts, where they remained for a brief time.

Before John Leonard's first birthday the family moved to New York State, settling on a farm near Preston, in Chenango County. John Riddell had expected financial aid from his father Gawn, but this was not forthcoming. Even at the death of Gawn Riddell (1812) his son did not benefit financially, the property falling into other hands. As a result the transplanted family led a struggling existence for many years. They lived in a small bark-covered log house, in the center of their farm. It was surrounded

> "by a wilderness, but . . . near an excellent fountain of water."
>
> *Personal Journal,* vol. 10

John Leonard Riddell's formal education began at the age of four. He attended a school kept by Polly Chase at the Corners, a mile distant from his home. He noted in his *Journal* that he

> "learned all the letters but 'm'."
>
> *Personal Journal,* vol. 10

He did not attend school during 1812, but was given "pious instruction," with hymn singing, under the supervision of his mother. During the next five years he attended the district school for short sessions in the summer and a few weeks each winter. Among his teachers were his aunt, Anna Gates, and his uncle, Nathan Noyes. He recalled that he became an excellent speller, and read the *Columbian Reader,* the *American Preceptor* and Smith's *Geography*. However he observed that he did not learn to write until he was twelve. He began the study of grammar in 1820, but did not really accomplish anything for several years. His studies did not include arithmetic until 1823. A year later he began Latin, reciting once a week to a Presbyterian clergyman in the neighborhood, and at the same time he continued his own reading in mathematics.

His interest in things scientific began in 1821, while he was supposed to be a student at his uncle's school. For one month out of the three month term he did not attend

> "for I got offended,"
>
> *Personal Journal,* vol. 10

and spent that month reading Spafford's *General Geography*. This text contained some elementary astronomy, chemistry and natural philosophy (physics), which were

> ". . . entirely new to me and which absorbed my whole attention. I resolved to become a philosopher, and forthwith set my ingenuity on the alert. . ."
>
> *Personal Journal,* vol. 10

Riddell's favorite instructor was John Brown, the schoolmaster in 1822. Brown, a student of medicine, was apparently a very good teacher, for he left a strong and excellent impression on young Riddell. Throughout these early years Riddell preferred to read on his own, rather than attend formal classes, such as they were. His reading was not confined to any particular field, and was quite extensive.

In 1825 Riddell attended the "Select School" of Mr. Sayre for three weeks, concentrating on algebra, and reading Ferguson's *Astronomy* in his spare time. After such varied and interrupted sessions he enrolled at Oxford Academy for four months (1826), studying under Rev. Mr. Andrus. Riddell wrote in his *Journal:*

> "My early opportunities for acquiring education were far from being superior. Until I was more than seventeen years of age I never saw the interior of a more dignified edifice devoted to learning than a common schoolhouse."
>
> *Personal Journal,* vol. 10

During part of each summer John Leonard was obliged to aid his father on the farm. This was extremely distasteful to him, and he records in his *Journal* that he received frequent floggings for his laziness, but

> "floggings only made me worse."
>
> *Personal Journal,* vol. 10

His first job was as mail carrier, on horseback, from Norwich, New York to Cortland, New York (1824). When he was eighteen (1825) he was appointed schoolmaster at Solon, Cortland County, New York, and received $7.00 a month for a three month term. He must have been successful, for the next year Lawyer Brush, father of one of his students, sent a special messenger to engage him to keep school in Truxton, New York at the increased salary of $10.00 per month.

One of the few intimate friends Riddell had was Randolph Williams, a boyhood chum who lived near him at Preston, New York. Williams, a slightly lame lad, was mischievous and the possessor of a daring and reckless disposition which matched Riddell's. In his later years Riddell remembered with much pleasure shady walks,

> "... orchards and plum yards of honest farmers so sadly subject to our nocturnal depredations,"
>
> *Personal Journal,* vol. 2

miniature gang warfare, midnight turkey roasts with stolen turkeys, and many imaginary ramblings and flights of fancy. The two boys traveled over the world together, investigating out of the way places. The source of the Niger River was, for some reason, of particular interest, and was referred to many times in later years by Riddell. Perhaps the whole friendship with Williams is best summarized by Riddell's phrase

> "his heart beats in unison with mine."
>
> *Personal Journal,* vol. 2

After his brief stay at Oxford Academy, Riddell spent two terms at Rensselaer School in Troy, New York, where he studied under the celebrated scientist Amos Eaton. His *Repository* contains classroom notes on courses in geology and botany, as well as lists of chemical apparatus and chemical formulae, which he termed "recipes." He received the Bachelor of Arts degree from Rensselaer in 1829.

Several years earlier (1826) Amos Eaton had provided for a Master of Arts degree, with the stipulations:

> "After the expiration of three years from the date of the aforesaid degree A.B. . . . if it is made to appear that he has sustained good moral character, and has continued to advance in the pursuits of scientific knowledge, he will be admitted to the second Rensselaer degree, to be denominated Master of Arts in Rensselaer School . . . it is intended to imply that his experience in the application of science to the arts, has qualified him in a higher degree to take charge of the instruction of others, and to give profitable counsel to the artist and to the agriculturist."
>
> *Rensselaer Rev. of Grad. Studies,* 1957, vol. 3, p. 4

Riddell applied for the Master of Arts while at Marietta, Ohio in 1832, and was duly awarded the degree. The charges for the degree were listed as $4.50.

Riddell's first scientific lecture was given on August 16, 1829, to the Rensselaer students, entitled "A New Theory of the Earth." In this talk he discussed the various geological formations found on the earth, and attempted to link these to the existence

and types of fossil remains found with these formations. He believed that originally the globe was covered with water, and that the earth was formed by

> "revolutions as a result of submarine fires and reactions of combustible materials buried beneath the ocean."
>
> *Repository,* vol. 1

After his graduation from Rensselaer, Riddell returned home and advertised for students for his own "Select School." The following notice was inserted in the Norwich, New York, newspaper, March 17, 1830:

> "Select School"
>
> "Mr. J.L.Riddell a graduate of Rensselaer School proposes to open a Select School in this Village on the 29th of March inst. in which will be taught the branches usually required. The School will be pleasantly situated in the south street.
>
> "For orthography and reading, per quarter $2.00
> Writing and first lessons in arithmetic and grammar 2.25
> Arithmetic, grammar and geography .. 2.50
> History, drawing maps and surveying .. 3.00
> Higher branches 3.50
>
> "Extra expences, eighteen pence per scholar. Mr. Riddell can assure parents and guardians that the moral as well as mental improvement of those committed to his care, will receive strict attention."
>
> *Repository,* vol. 2

But the job of a district schoolmaster did not appeal to the young scientist. After one term he decided to earn his livelihood as a traveling lecturer in chemistry.

III. PERSONAL CHARACTERISTICS

Facts about Riddell's personal life and character can only be pieced together from fragmentary sources. We are told that he was extremely good-looking, with rosy cheeks and a delicate skin. He had high cheek bones, a Riddell family characteristic. He was endowed with a certain amount of charm, pleasing manners, and a large proportion of ego.

Riddell had the unfortunate habit of captivating young women, beginning in his early years, when he noted his first love affair with Emeline Brown (1822). Emeline was an

> "exceedingly pretty black-eyed miss and the daughter of a black smith."
>
> *Personal Journal,* vol. 10

He also fell in love with one of his first pupils, Sarah Ann Hawley (1825). These were but the initial events in a long chain of affairs, some petty and some serious, which continued even after his marriage in 1836. These affairs frequently went beyond the bounds of propriety, and caused him to lose favor in several communities.

In his adult years Riddell was termed an eccentric, always outspoken and pompous, extremely cynical, and eager for personal improvement. He wrote and spoke in a manner designed to produce an effect, using words and phrases frequently ill-suited to the topic at hand, but capable of creating the impression of grandeur. His own summation of his adult behavior seems to fit perfectly:

> "I conduct myself with considerable reserve and hauteur."
>
> *Personal Journal,* vol. 1

Riddell kept a *Personal Journal* beginning with his graduation from Rensselaer, and continuing until 1849. In later years he recorded his family genealogy and some facts about his early life. He also kept a *Repository,* a record of scientific problems, inventions, notes on lectures, theories and sketches of apparatus, and many miscellaneous jottings. For a short time he also kept a *Depository,* consisting of bits of poetry and prose. Most of these have a spicy tinge. The existing volumes of these three journals are deposited in the Howard-Tilton Memorial Library of the Tulane University of Louisiana, New Orleans, Louisiana.

Riddell's *Repositories* and *Journals* are filled with incomplete sketches, diagrams, descriptions and speculations on all sorts of subjects. Only a few of these were ever completed, or even described in such fashion that they could be followed. A few comments on some of these will be given.

Museum Specimens.

Riddell suggested the injection of a low fusing point alloy into the arteries of ani-

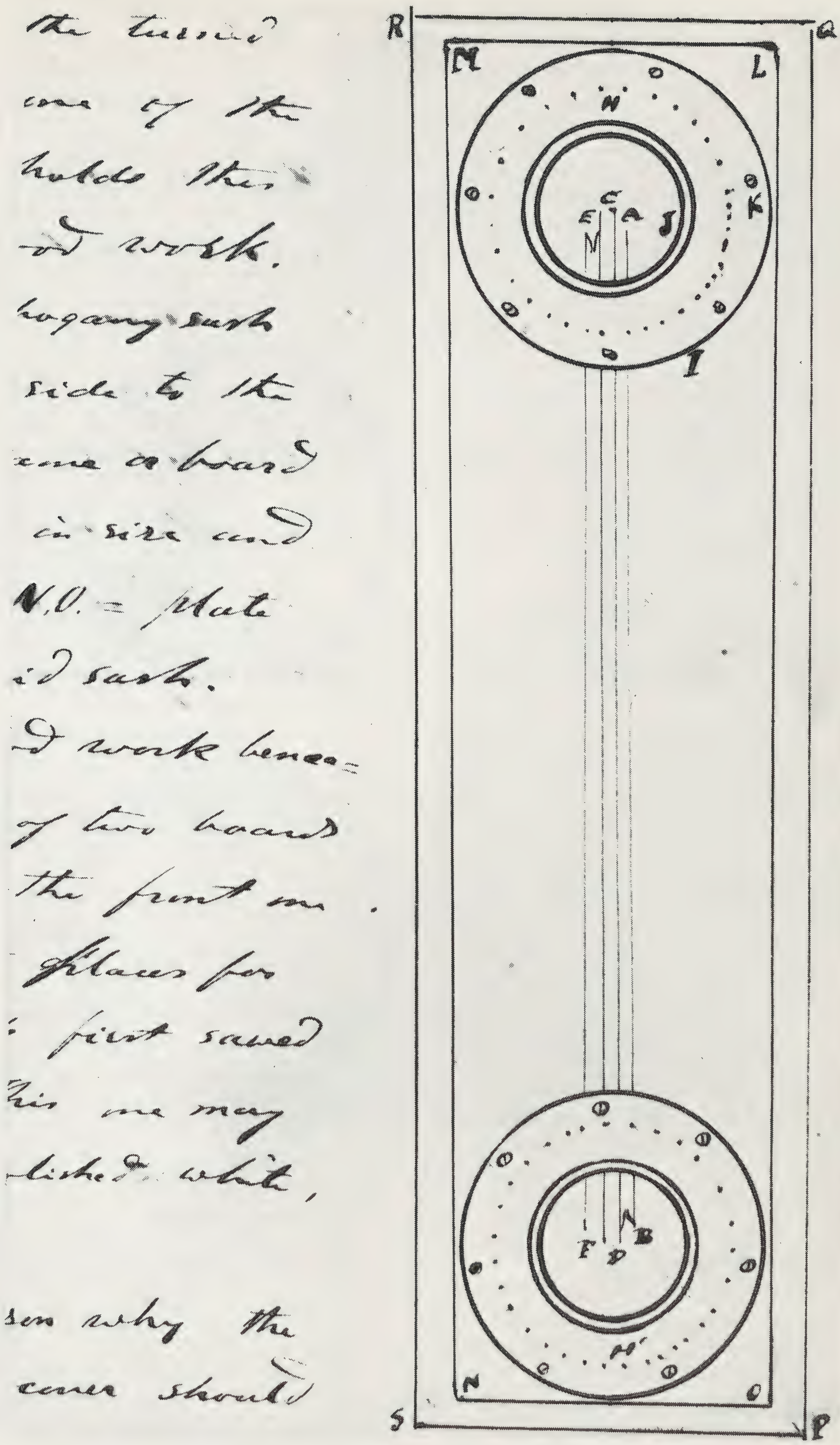


Figure 2. Page from one of Riddell's Personal Journals (Howard-Tilton Memorial Library, Tulane University).

mals, then, after hardening, the removal of the organic matter. The shaped alloy remaining could be placed in a glass case for display purposes.

Recipes.

His early *Journals* (1829,1830) contain "recipes" or directions for making various substances. Most of these were not original, but were copied from his reading. The interesting thing is the variety of topics which attracted him enough to be inserted into the *Journal:* notes on cements and lutes; directions for silvering mirrors; directions for producing fire; composition of rockets; composition of glass; soft glass for jewelry; spruce beer powders; soda powders; lemonade powders; notes on removal of stains; matches and percussion powders.

IV. EARLY LECTURES – OGDENSBURG AND BROCKVILLE 1830-1831

John Leonard Riddell's early lectures in chemistry and in botany consisted of basic fundamentals obtained from Amos Eaton's lectures at Rensselaer and from his own reading. There was very little original material in them. The first series was given in Ogdenburg, New York, in the fall of 1830. He was well received in Ogdensburg and in Brockville, Ontario, Canada, but he barely made a living. It was his practice to solicit letters of introduction to prominent citizens in a town, and then call on these men and ask them to sponsor his series of lectures. Riddell seemed to feel that it was natural for him to receive such sponsorship even if he was a total stranger to the men concerned. When he was unable to secure the support he sought he was quite indignant and often bitter, as his records indicate.

Riddell had purchased sufficient scientific apparatus for his lectures, and entered each item in Volume 1 of his *Repository.* The total expenditure was about $25.00. His first series in Ogdensburg netted a profit of $38.32, (January, 1831). In addition to his series of lectures in chemistry he planned a series of botanical lectures in an attempt to support himself in a more substantial fashion. He also tried his hand at chemical analysis, devising a gravimetric method for analyzing a specimen of potash, but was not paid for his efforts as he had expected.

During this period Riddell contemplated writing a "popular and systematic botany" and compiling a series of florae. He was also reading medical textbooks and collecting minerals and plants. Riddell's *Repositories* are filled with detailed descriptions of formations, locations of ores, mineral springs, natural waters, etc. encountered on his many field trips. He wrote a paper on the geology of the St. Lawrence region, but did not publish it. His reports are characterized by general descriptions, substantiated by personal references and conversations with the inhabitants of the region. His non-scientific reading included Byron; Cervantes's *Don Quixote;* Johnson's *Rasselas;* Blair's *Harmony of Sentences, Lectures on Modern Eloquence* and *Lectures on Style;* Scott's *Waverly;* and Homer's *Odyssey.*

For recreation Riddell took long walks along the banks of the St. Lawrence River, frequently alone, but occasionally in the company of his friend Marsh or some congenial young lady. He practiced fencing and the

> "broad sword exercise,"
>
> *Personal Journal,* vol. 1

and played billards and whist.

Riddell and his friend Marsh had an extended discussion on a new theory of the solar system which Marsh had postulated. What the exact principles of the theory were we do not know, but Riddell was certain that it would account for the motion of the planets, but would fail in other areas. According to the Riddell version,

> "the earth is not directly attracted to the sun's center, but to some other point. Wherefor the direction of the centripetal force which arises from the sun's attraction varies from the direction of the other force. If these suppositions were established we should infer that there was a constant impulse arising from the rotation of the sun that acted to impel the earth forward in its orbit."
>
> *Personal Journal,* vol. 1

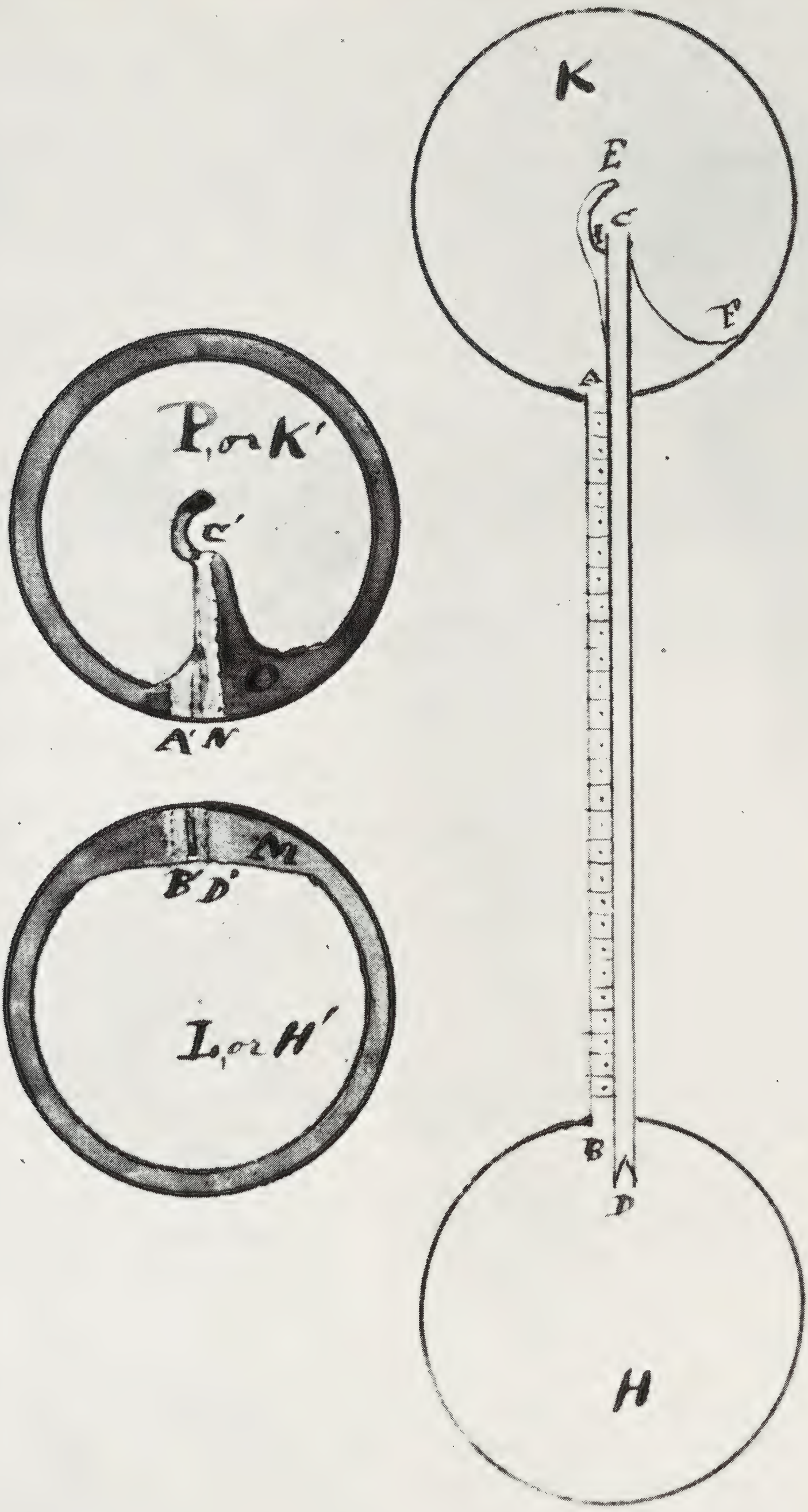


Figure 3. Drawing of Riddell's modification of the barometer, as given in his *Personal Journal* (Howard-Tilton Memorial Library, Tulane University).

Riddell considered the following analogy for the planets:

> "Planet is in the condition of a boat drawn on water by two ropes, pulling at an angle so obtuse as to seem in a line. Yet the angle of the ropes always remains the same. In the same manner the motion of the earth is kept up by the joint action of centrifugal and centripetal forces that vary little in direction. The centrifugal arises of course from the curvilinear motion of the earth in its orbit, and as the earth would fly off in a tangent to its orbit the center of which is the center of the sun, if this force alone existed it may be inferred that the direction of the centrifugal force is from the sun's center."
>
> *Personal Journal,* vol. 1

One of his amorous affairs in Ogdensburg probably turned some of the more staid citizens against him, for when Riddell wanted to borrow some scientific apparatus for lectures in Brockville he was promptly refused. He did secure some letters of introduction, and later traveled from Ogdensburg to Prescott to Brockville.

While in Ogdensburg he made a decision of importance, one which certainly influenced his future. He had to choose between accepting a full time teaching position in Ogdensburg, continuing his lecturing, establishing a school of his own, or returning home and studying medicine by himself. Since he was in financial straits, and could not call on his family for assistance, the last two alternatives were not feasible. He was not particularly interested in teaching because of his early experiences, for he wrote.

> "O Heavens, for my existence sake, deliver me from the thankless task of teaching a room full of hard-headed, thick-pated, mischief-making boys!"
>
> *Personal Journal,* vol. 1

So the decision to continue lecturing was inevitable.

His diary contains many bits of peculiar poetry and many indications of loneliness. Riddell was not accepted into the social circles in Ogdensburg, or in any of the other towns he visited, as he desired.

> "Untoward circumstances, yes poverty, unrelenting poverty, now oppose an insurmountable barrier to my advancement. I was fired by ambition and vainly hoped to redeem an empty name from that bottomless gulf of oblivion into whose dark waters is whelmed the memory [of] the mass of human beings. Paralyzed by the influence of sad experience, should I now be set back to the years of my childhood, I would not aspire to raise myself above the level of contented insignificance."
>
> *Personal Journal,* vol. 1

Although he was in financial straits, Riddell bought

> "two pairs of fashionable white pantaloons and two linen shirts with plain bosom,"
>
> *Personal Journal,* vol. 1

on credit, because he felt he should be seen in proper attire.

Riddell left Ogdensburg on June 8, 1831, traveling by boat to Morristown, New York, where he had an argument with the captain over the charge for his passage. Riddell commented

> "I would have given half a kingdom for a sword or a dirk. . .,"
>
> *Personal Journal,* vol. 1

with the result that his baggage was spilled over the dock. Commandeering a wheelbarrow, Riddell loaded his property and proceeded to the nearest tavern. He ferried from Morristown to Brockville, but this, his second visit, was not as pleasant as his first. The attitude of the citizenry was hostile, due to a widely publicized love affair with a Mrs. Crawford, daughter of the Sheriff, during his first visit. Riddell noted that Mrs. Crawford was

> "young, sprightly, dark-eyed and very pretty."
>
> *Personal Journal,* vol. 1

At two or three tea parties at her home, in the absence of her husband,

> "she behaved very indiscreetly and I could scarcely do less . . . I believe we both fell seriously and painfully in love."
>
> *Personal Journal,* vol. 1

Dr. Crawford, the husband in question, was polite enough to Riddell, and invited him to drink with him, but openly opposed his lecture series.

He had a letter of introduction to Archdeacon G. O. Stewart, who received him coolly at first, but later gave him a letter and support. A clipping from the Brockville newspaper announcing his lectures bears the signatures of the Archdeacon and of B.

Bidwell, another well known citizen. His diary notes that

> "I have a high idea of the virtue, integrity and benevolence of the clergy. . .,"
>
> *Personal Journal,* vol. 1

a statement which he refuted on other occasions. In spite of the endorsements the second lecture series at Brockville did not materialize, so Riddell moved on to Kingston, Ontario.

V. WANDERINGS – 1831-1832

During the first week after his arrival in Kingston Riddell called on those citizens to whom he had letters of introduction, solicited their sponsorship for his lectures, attended teas and soirées, and was quite careful to remain on good behavior.

> "I must sacrifice my feelings to interests in some cases when I have made a circle of acquaintances I feel impelled by pride and honour to support by rank. . ."
>
> *Personal Journal,* vol. 2

The first lecture was given on June 19, 1831. The editor of the Kingston *Patriot* commented favorably:

> "Riddell is quite a young man, but evidently master of his subject, and abundantly able to illustrate it by numerous interesting and instructive experiments, for which he is provided with neat and compact apparatus. The youth of Mr. Riddell, we consider, greatly to strengthen his claim to encouragement and support, for a spirit of emulation is invariably the fruit of nurturing the splendid results of early and unwearied application to the sciences."
>
> *Personal Journal,* vol. 2

A full prospectus describing his lectures was prepared by Riddell and appeared in the Kingston *Herald,* June 22, 1831.

> "Mr. Riddell, being a lover of the natural sciences, adopts the means of making a sort of Linnean pilgramage through the Canadas. The wild productions of the forest and the varied subjects of the mineral kingdom are what he wishes to become acquainted with. And he knows of no avocation that would afford greater facilities to the pursuit of his favorite subject than that of an errant lecturer on chemistry."
>
> *Personal Journal,* vol. 2

Topics included in the proposed course were:

> "The cause of heat. The various natural phenomena produced by that subtile agent. Divers methods of producing heat spontaneously and of causing a degree of cold sufficiently intense to freeze water in a warm room. Electrical experiments with the several theories and doctrines of electricity. Proximate cause of lightning. Reasons why its course is sometimes forked or angular. Relation of light and heat. General view of attraction. Affinity, the foundation of chemical science. Atomic propositions. Scale of equivalents.
>
> "Note: the department of pneumatic chemistry will be but very little abridged. The elementary supporters of combustion and the simple non-metallic substances will all be duly considered and their properties faithfully illustrated with experiments.
>
> *Personal Journal,* vol. 2

The following experiments were planned:

> "Burning iron wire in a vessel of oxygen gas; burning phosphorus in a vessel of oxygen gas; bleaching prospect of chlorine; combustion of a brass wire and other substances in that gas; experiments with iodine; art of etching glass with fluorospar; experiments with hydrogen – philosopher's candle, musical sounds, strange effects of platina sponge; pneumatic balloons; aerial navigation. Analytick and synthetick composition of water. Nature and properties; composition of the atmosphere; properties of nitrogen. Nitrous oxid or exhilarating gas. Nitrogen compounds. Sulfur and its compounds. The mephitic air that charges the water of many springs. Experiments with phosphorus. Charcoal. Choke damp of mines. Limestone composition. Inflammable hydrocarburets; inflammable gas burned in cities, etc."
>
> *Personal Journal,* vol. 2

This prospectus for a series of twelve to fifteen lectures was indeed ambitious. Many of the topics proposed for discussion are in the realm of physics, while the experiments are strictly chemical. Riddell's careful technique of demonstration, tending toward the spectacular, and his detailed explanations, made his lectures much appreciated by the scientists in the audiences, and enjoyed by the general public. The cost of the series was twenty shillings for one ticket; one pound, ten shillings for two tickets; two pounds, five shillings for a family ticket; or two shillings, sixpence for a single lecture.

On June 25, 1831, he noted in his *Journal* that he had left Norwich and school

teaching one year, and somewhat bitterly remarks that

> "I have witnessed a variety of scenes, passed through novel adventures, and seen various shades of human character, etc. which, with my former experience, serve to confirm the truth that the best friend a young man has in a strange land is his own dear self."
>
> *Personal Journal*, vol. 2

He was homesick and lonesome, and often wished that he

> "had his apparatus off his hands,"

and

> ". . . a less disagreeable way of obtaining a livelihood."
>
> *Personal Journal,* vol. 2

Perhaps the most important acquaintance Riddell made while in Kingston was William LeConte, the eminent naturalist. He made several field trips with LeConte, and had many discussions with him on scientific subjects. Riddell proposed a type of symbolic shorthand for presenting botanical descriptions and asked LeConte to support him. LeConte thought that such a scheme might be desirable, but that it was certainly impracticable.

While in Kingston Riddell read Spencer's *Faerie Queene,* Shakespeare's *Julius Caesar* and *Macbeth,* and A. F. deFourcroy's *Chemistry.* During this period he again evidenced much interest in the study of medicine, listing desirable books for a medical library in his diary. These included Charles Bell's *Anatomy;* Bell's *Nervous System;* Samuel Cooper's *Surgery;* Bell's *Operative Surgery;* Magendie's *Elements of Physiology;* Eberle's *Materia Medica;* James Burns's *Obstetrics;* Gregory's *Practice of Medicine;* the *American Pharmacopeia;* Webster's *Manual of Chemistry;* Chapman's *Practice of Medicine;* Hooper's *Medical Dictionary;* and a few others. Some of these texts are regarded as medical classics today.

The itinerant lecturer traveled from Kingston to York (now Toronto) and then to Erie, Meadville and Pittsburgh, Pennsylvania and Wheeling, West Virginia. At Erie he lectured at the Courthouse on "Geology and Mineralogy," November 17, 1831. This was the first public lecture in this field. At Meadville, Riddell's baggage fell into the river, damaging his books and his apparatus. He instituted legal proceedings to recover damages, but there is no record of success.

Riddell's general concept of science is given in a note prefacing a lecture given at Meadville, Pennsylvania, in 1832. He divided Natural Science into Natural Philosophy (Physics), Natural History, and Chemistry. He felt that it was impossible to

> "draw the line of demarcation between them and say where one science ends and another begins.
>
> "Natural history considers the infinitely varied productions of nature, as they are left by the operation of nature's laws or the hands of the original Creator. Hence the natural historian makes himself acquainted with the habits and appearances of animals, plants and lifeless minerals, and these he studies in their native condition, disregarding the changes effected by the art and ingenuity of man.
>
> "Natural philosophy investigates and explains the properties, motions and relations of material bodies, without any regard to their inherent composition. It is the laws of nature, developed by natural philosophy; that poise the heavenly bodies and direct the distant planets in their trackless orbits through the regions of empty space. . .
>
> "It is the province of chemistry to seek out the elements of matter, which in their varied combinations assume appearances so widely different and to investigate the nature and cause of the numerous changes to which they are liable.
>
> "Both chemistry and natural philosophy investigate the laws of inorganic matter. But they differ in this: that natural philosophy explains the perceptible motions of natural bodies in mass, such as the momentum of falling bodies, the pressure of fluids, and the force and effects of planetary attraction, whereas chemistry considers the insensible motions incident to the elementary atoms of which these bodies are composed, such as the solution of sugar in water, the formation of clouds, and the slow decay of organic matter."
>
> *Personal Journal,* vol. 5

His definitions of the sciences follow the usual pattern of the times, but the pharseology in the last paragraph is genuine Riddell. He referred continually to momentum and to the planets, often erroneously.

On arrival in Pittsburgh Riddell boarded at Mrs. Reynolds's for $3.00 per week, provided that he make his own fire. Again his

youthful instincts led him into difficulty, for Mrs. Reynolds asked him to leave after a short stay. His initial gratuitous lecture was given on February 20, 1832, in the Grand Jury Room. A second lecture, on "Chemistry and its Application to the Arts and Manufactures" was given on the following day. He was unable to secure sufficient subscriptions for his course of lectures, but did engage in many discussions on scientific subjects, principally with Dr. Bruce, president of the Western University of Pennsylvania. Their discussion concerned

> "the ratio in which air or other fluids would impede a body moving with different degree of velocity."
>
> *Personal Journal,* vol. 4

Bruce maintained that

> "the obstruction of air was directly as the square of the velocity,"
>
> *Personal Journal,* vol. 4

but Riddell remarked

> "now though that is undoubtedly incorrect I will make some calculations thereupon."
>
> *Personal Journal,* vol. 4

And then he proceeded to calculate for four pages, deriving a complex formula for the velocity of particles moving through a resisting medium in terms of the diameter of the particle.

Later he changed his opinion and accepted the proportionality Bruce stated, for in some of his aerial calculations he lists the following three assumptions:

> "Resistance of medium proportional to v^2 of moving body.
> "A cylinder moving endwise through a resisting fluid encounters four times the resistance of a sphere of the same diameter and moving with the same velocity;
> A spherical drop of rain of 1/10 inch in diameter would have, in falling through air, a terminal velocity of 10.48 ft/sec."
>
> *Personal Journal,* not numbered.

Riddell also noted at least three amorous adventures while in Pittsburgh, describing these in wistful terms.

Riddell traveled by river boat down the Ohio River to Wheeling, West Virginia, arriving on April 30, 1832. He registered at the Wheeling House, paying $4.00 per week. He duly noted that he was being overcharged, since most of the other boarders paid only $3.00. He was successful in securing subscribers for his lectures, which began on May 9 in the Masonic Hall. His fees for the series were $5.00 single, $7.00 couple and $10.00 per family, for fifteen lectures.

On May 20 he moved to Washington Hall, with William B. King as landlord. It was at Washington Hall that one of the unfortunate occurrences of his early life took place. Riddell attempted to seduce one of the chambermaids in the boarding house, but another maid discovered them and notified King. Riddell was obliged to leave, not only the house, but the town, because of the magnitude of the story which was circulated. A Dr. Townsend came to Riddell's defense, but none of the newspapers would print anything of the affair. In spite of the adverse publicity because of the incident, the Wheeling lectures were quite successful.

Perhaps the most interesting acquaintance made at Wheeling was the subject of the following paragraph:

> "Met with eccentric old schoolmaster whose mental faculties are strangely organized. His name is Hildreth. The citizens all believe him bordering on insanity. He seems indeed to suffer under a kind of mental alienation or rather perversion, but I have little doubt it has its origin from the intense zeal with which he pursues a few delusive theories which have sprouted in his own brain. He has observed a universal key to all knowledge and science, whether moral, philosophical, natural or supernatural."
>
> *Personal Journal,* vol. 4

From Wheeling, Riddell journeyed to Marietta, Ohio, and became a

> "temporary professor of astronomy, geology, botany and chemistry at the female seminary in Marietta. . .,"
>
> *Personal Journal,* vol. 4

for which he taught three hours a day, and gave lectures twice a month, for a salary of $30.00 a month.

VI. MARIETTA – 1832

Riddell's *Journal* places him in Marietta, Ohio, on June 25, 1832, living with the very religious family of the Widow Robins. His room and board amounted to only $1.00 a week, but he complained about the food, and lived mostly on milk and bread. Once a

week the boarders were served fresh meat. Pork and butter were available more frequently, but Riddell did not care for them.

In his early wanderings he had made occasional references to religion and to church attendance, but it was in Marietta that he took occasion to enter his comments at length. He wrote

> "We live upon the Holy Scriptures, family prayers and very plain food . . . I should not be popular among them if I remain, because they cannot sympathize with my unregenerated state. I become more and more of a hypocrite the longer I live, when several years younger I had spurned the idea of redeeming mankind so I hide my real sentiments by silence . . . We are all religious here."
>
> *Personal Journal,* vol. 5

Household prayers were part of the daily routine, and they irritated Riddell considerably. He complained:

> "O! I am tired with and of these long prayers!"
>
> *Personal Journal,* vol. 5

Riddell had some religious training under his mother, but in his adult years he became a free thinker. He did not belong to any particular denomination, yet while lecturing he attended church quite regularly. He would visit with one congregation for the morning service, and another for the evening service. He looked upon church services primarily as an opportunity to meet some of his young ladies or to exchange amorous glances, or to visit with some of his patrons. He had little regard for the preachers or their sermons, although he counted them among his patrons on many occasions. Riddell believed in God, there is no doubt of that, but he was not able to accept all of the doctrines of any particular sect. On one occasion (1831) he noted that he had never attended a Catholic church, so he went once, and then devoted several pages of his *Journal* to comments on the service. The Mass reminded him of magic hocus-pocus, linked with conjuring spirits from the deep. Perhaps he was a bit bitter on that occasion, because he indicated, with sarcasm, that he was not invited to sit in one of the family pews, but was forced to sit in the gallery. In spite of his interest as it was in religion, Riddell frequently went on a country ramble instead of attending church.

At Marietta he realized that he would gain greater support for his lectures if he

> "attached himself to one of the powerful Christian denominations . . . but I have fancied myself mentally above those fabrics of superstition and I prefer the credit of an independent mind and honest sentiment which have some foundation in reason, to the temporary advantages arising from hypocrisy."
>
> *Personal Journal,* vol. 5

And somewhat later he concludes

> ". . . it really seems to be that the leading features of the Christian creed are absurd to the last degree . . . what is Christianity but a huge fabric of polytheism and idolatry?"
>
> *Personal Journal,* vol. 5

Obviously he was not temperamentally suited for a religious environment, and did not enjoy his stay in Marietta.

The days at Marietta did bring about a change in his emotional state. Perhaps this change was due to the Wheeling incident, for he mentions only one amorous situation while at Marietta, with Hannah, the daughter of the Widow Robins.

> "I fancy we shall fall moderately in love in the course of the week. . ."
>
> *Personal Journal,* vol. 5

After random sentiments about persisting in celibacy, he outlined his thoughts on marriage, which are indeed characteristic, and fit his temperament and disposition perfectly.

> "If by an honourable marriage with an agreeable female I can materially improve my prospects and better my worldly conditions, if I can possess myself of competence and connect myself with highly respectable families, I will certainly adopt the matrimonial state. But marriage under other circumstances will but cut short my agreeable wanderings and fetter my cherished schemes of ambition."
>
> *Personal Journal,* vol. 5

This is quite a change from his early point of view, when he contemplated marriage solely for companionship and relief from loneliness.

While in Marietta he had the opportunity to collect many specimens, and exchanged various plants with Constantine Samuel Rafinesque and other botanists. Although he was not too happy he was quite successful in his scientific work.

> "The Lyceum in this place, with several private individuals, have made up a subscription of $73.70 to have me examine the wild plants which grow about here."
>
> *Personal Journal,* vol. 4

This was, of course, in addition to the fees received from his teaching and from his lectures.

But the young scientist was still uncertain about his future. Every letter from his family in Preston, New York, would evoke some reminiscent jottings in his *Journal.*

> "My boyish comrades are plodding on the same old homely sober path, content to see as little of the world as their fathers. . ."
>
> *Personal Journal,* vol. 5

He would like to renew acquaintances with some of his old friends, particularly Randolph Williams, but

> "I am confident I could not enjoy their company as well as formerly. Therefore I cannot let the recollections of old times controul my better interests."
>
> *Personal Journal,* vol. 5

One of his loyal friends at Marietta was Dr. Samuel Prescott Hildreth. Dr. Hildreth was an individual of considerable influence among contemporary scientists, and was most helpful to Riddell. The two carried on an extensive correspondence for many years. It is unlikely that this is the same Hildreth referred to in the Wheeling quotation.

An important change in Riddell's scientific work occurred in Marietta. The emphasis shifted from chemistry to botany. His interest in botany stemmed from his student days in Rensselaer. His notebooks are filled with references to collecting, exchanging of specimens, directions for preservation of specimens and the preparation of catalogues. He began his own herbarium in 1830.

For example, he was careful to direct that only an oil-cloth bag be used to collect specimens, and that a special type of portfolio be used for carrying specimens. He recommended a 10 x 16 inch portfolio, containing about three hundred pages of

> "soft, bibulous paper"
>
> *Repository,* vol. 5

in covers, with the back cover twice as thick as the front. He designed a special shoulder strap and attachment for the portfolio. Detailed directions for the proper use of the portfolio and for preparing herbaria are given in several places in the early *Repositories.*

Riddell's first botanical paper was printed in the Marietta, Ohio, *Western Republican* on September 1 and 7, 1832, entitled "Notice of the vegetable productions growing spontaneously in Washington County, Ohio." The paper was addressed to the Marietta Lyceum, and in it he employed the catalog system of Jussieu. On July 6, 1832, he had inserted in the same newspaper a preliminary accouncement of the paper, and solicited customers for herbaria. He also prepared a manuscript for the Marietta *Friend and Gazette* based on one of his lectures at the Female Seminary, entitled "Vegetable Relationship" (1832) but signed it with a pseudonym, Raymond Lully, Jr. The *Catalogus plantarium Mariettae* was begun in 1832, but there is no record of its publication. Most of the material appears in his later works on Ohio plants.

In many of his botanical projects Riddell expressed his disapproval of the Linnaean system of classification, preferring the modified systems of Amos Eaton, John Lindley or Augustin Pyramus de Candolle. From time to time he inserted glossaries of botanical terms in his notes.

Riddell was always experimenting with new methods for preparing herbaria. He tried a quick drying method based on the insertion of a quicklime sieve between the layers of paper in the drier. He used the lime to keep the air of the herbarium case dry, and

> "therefore no living thing can exist there and no chemical changes can go on.
>
> "My plans consists in wholly abstracting the moisture from the specimen to be preserved, having previously inclosed it in some material impervious to air or moisture in order that the condition of absolute dryness may be perpetually maintained. The dessicative substance which I make use of is unslacked lime."
>
> *Am. Journ. Sci. and Arts,* 1839, vol. 35, p. 338

This method was successfully used on *Asclepias Drakeana* and other flowers. Their colors were not affected by the lime. He also

designed an axle press, and, later, an elaborate drier and preservation cabinet for use in New Orleans, based on a charcoal furnace. His general directions for collecting and preserving were published in the *Western Journal of the Medical and Physical Sciences* (Daniel Drake's Journal) as "Particular directions for collecting and preserving specimens of plants, extracted from an unpublished treatise on practical botany."

Riddell maintained a large and complete herbarium for his own use, as well as a supply of specimens for sale. He advertised "suits of plants" or collections wherever he lectured. His usual price was $3.00 per hundred specimens during his early wanderings, but later this was raised to $4.50. The price was quite reasonable.

VII. WORTHINGTON – 1832-1834

From Marietta, Riddell went to Worthington, Ohio, as professor of chemistry and botany at the Ohio Reformed Medical College. This institution, truly a "reform" school in its theories of medical instruction, had two professors, Dr. Thomas Vaughn Morrow and Dr. Ichabod Jones. These men gave Riddell a chance to attend the first formal lectures of his life in the various branches of medicine.

In December, 1832, Riddell began his lectures at the Lyceum in Worthington. He became acquainted with the members of the Ohio Legislature who were trustees of Ohio Reformed Medical College, and frequently attended sessions of the Legislature in Columbus. He was only moderately pleased with his post at Worthington.

> "If I could modify the title and character of this college I would be willing to remain a year or two."
>
> *Personal Journal,* vol. 7

His *Journal* contains references to field trips, studying the botany and geology of the region, letters to Dr. Hildreth, and some references to his personal life in Worthington. Drs. Morrow and Jones frequently called on him in his room, and they engaged in many discussions. Riddell was bold enough to ask a Mr. Bye, state senator from Marietta, to propose him for membership in the Ohio Historical and Philosophical Society. He was admitted to membership several years later, January 7, 1835. Perhaps the most human aspect of his *Journal* during this winter is his frequent reference to the coldness of the winter and continued bad weather.

Riddell was still looking for a permanent position. He asked Hildreth to communicate with Dr. Daniel Drake in Cincinnati, Ohio, to see whether there was an opening for him there.

Another interesting aspect of the Worthington period was a change in point of view toward religion. This was brought about by Miss Mary Catherine Burr, a

> "slim, handsome, healthy female!
>
> *Personal Journal,* vol. 7

He then proceeded to describe her in medical terms:

> "Pulse full, vigorous and soft; eyes sparkling and occasionally varnished with the lachrymal fluid; tongue clean and moist; cheeks suffused with red; teeth white and hard; epithelium exceedingly tempting. Form rather slim, but finely turned. Temperament decidedly sanguineous."
>
> *Personal Journal,* vol. 7

During the next few months Riddell became infatuated with Miss Burr, so much so that the community regarded them as engaged. Miss Burr, an Episcopalian, had a brother who was the preacher in Worthington, so Riddell attended church four times each Sunday – Sunday School, morning worship, evening service and the meeting of Sunday School teachers. There is no doubt that he was doing this to be near Miss Burr, for he once remarked that if they would separate he would attend only once a Sunday. The young suitor made quite a point of trying to find out just how much Miss Burr was worth. Estimates ranged from $20,000 to $1,000. He even attended temperance meetings and participated in their programs, speaking on the physiological effects of alcohol. His roommate during this period, a Colonel Morrow, was not congenial with the eccentric scientist. There were numerous feuds, but

> "no lives lost though there was some skin broken."
>
> *Personal Journal,* vol. 7

While in Worthington, Riddell was very concerned about his family. He had hoped to be able to send help to them, but found himself unable to do so. He stated frequently that he did not marry because of his family. He was very proud of them and of their potentialities. In his *Journal* we find

> "I have brothers who were formed by nature to be useful, honourable and perhaps distinguished. Sisters have I who might, with a proper education and in proper circumstances, be an ornament to their sex."
>
> *Personal Journal,* vol. 7

John Riddell, father of John Leonard, died in Preston, New York, on May 10, 1833. His eldest son received the news in Worthington on May 29, and was deeply affected. This increased his anxiety for his family. Since his father had been a tenant farmer he wrote immediately to Mr. Guy Richards of New London, Connecticut, the holder of the title to the farm, and asked his indulgence.

> "I trust that you will not oppress them, or drive them from their only home, but allow them to derive a living from the land which my illustrious father has cleared and cultivated with his own hands."
>
> *Personal Journal,* vol. 8

A few days later he wrote:

> "I do feel as if much of the interest in life were gone; for the approval or admiration of my father of what I might do or accomplish would give me more true pleasure than the voice of all the world besides."
>
> *Personal Journal,* vol. 8

Riddell advised his mother to remain on the farm with the children, and not to bind them out to any trades. He then asked her advice on his marriage

> "to a girl, young, handsome and accomplished, with $3,000 in ready money."
>
> *Personal Journal,* vol. 8

Curiously, in this exchange of letters about his father Riddell lapsed into the old spelling of the name, Riddle, which his father apparently used. In another letter he had initially written Riddle, but deleted the last two letters and substituted "ell".

For several months he debated whether or not he should tell Miss Burr about his father's death. He did succeed in finding out that her exact wealth was between $1,000 and $2,000. Miss Burr was much attracted to the young scientist, and eventually told him that she was in love with him. It was after this that he had courage enough to tell her about his father, but then explained that he was unable to ask her to marry him at that time. They parted at the end of March, 1834, when Riddell left Worthington.

On July 25, 1833, Riddell planned a lecture series on the "philosophy of atmosphere and terrestrial changes," which would contain as topics for discussion:

> ". . . attributes of matter; atomic theory; different states of aggregation of the particles of matter; all the more common phenomena produced by caloric; deposition of dew; ascent of vapour; formation of clouds, rain, hail, snow; cause of winds; meteors (which will involve electricity) . . . nature and composition of the atmosphere, ice, fountains, rivers, saline springs . . . degradation of land-causes now modifying earth's surface-ancient revolutions."
>
> *Personal Journal,* vol. 8

He attempted to design an apparatus for the determination of the extent of the atmosphere. He believed that if he had the precise height of the atmosphere he could use the data to calculate the size of aerial particles.

Riddell observed showers of meteors at Worthington on November 13, 1833. He prepared a paper based on his observations for the *Ohio State Journal,* Columbus, Ohio, on November 16, 1833. A copy of his report was sent to Professor Denison Olmsted of Yale University, who quoted from it in his publications on the same showers.

While in Worthington, Riddell began his "Catalog of plants growing spontaneously in Franklin County, Central Ohio, excluding grasses, mosses, lichens, fungi, etc." This was published in two installments in the *Western Medical Gazette* in 1834.

Riddell's major botanical work during this period was his "Synopsis of the flora of the Western States." The work was begun in Worthington, and completed in Cincinnati. In the preface Riddell wrote:

> "It has for several years been the author's design to publish a flora of the Western States when he shall have accumulated a sufficiency of materials; and he takes this opportunity of soliciting information from those who may

> choose to favor him with their correspondence, and of proposing an interchange of botanical specimens with all who may wish to form collections . . . The following catalogue, though necessarily incomplete, will probably aid in effecting the desired object, by exhibiting its present state of advancement, thereby enabling observers located in different sections of the assumed territory the more easily to make additions to it."
>
> *West. Journ. Med. and Phys. Sci.,* 1834, vol. 8, pp. 329-374

This catalog is generally regarded as a contribution of major importance, the first devoted entirely to Western flora. It contained listings of 690 genera and 1800 species, with appropriate notes on localities and growth habits. The work, however, was not completely original, as was the Franklin County paper. His boundaries for the Western States extended

> ". . . from the Alleghany mountains in West Virginia to the Platte River in Missouri Territory, and from the southern boundary line of Tennessee to the latitude of Detroit,"
>
> *West. Journ. Med. and Phys. Sci.,* 1834, vol. 8, pp. 329-374

covering a large area. He "borrowed" the Kentucky plants from works of Dr. Charles Wilkins Short, and those around St. Louis, Missouri, from Dr. Lewis C. Beck, and those of the Missouri Territory were obtained from the collections of Thomas Nuttall. The work, nevertheless, was favorably received. A clipping from a Cincinnati newspaper stated:

> "Mr. Riddell is very well known to many in this city as an able, enthusiastic and indefatigable votary of science. The pamphlet before us bears ample testimony to this character, even if other evidence were wanting. To those who are pursuing the study of botany this little book will be valuable . . . We have high authority for pronouncing the arrangement good and the work very creditable to the author."
>
> *Repository,* vol. 7

The *Flora* was published by Dr. Daniel Drake in the *Western Journal of the Medical and Physical Sciences,* and also in pamphlet form by E. Deming in Cincinnati (1835). Thirteen new species were listed, of which only two are attributed to Riddell today:

Solidago Ohioensis and *Trillium nivale.*

Riddell had studied the *Characea* before publishing the *Flora* and had included several in his compilation which he thought new, but there is some dispute about them. He dedicated a new species of *Euphorbia* to his Cincinnati roommate, Dr. Otho Herron, *Euphorbia Herronii.*

About this time Riddell became acquainted with the German botanist Dr. Joseph C. Frank, who was visiting in Cincinnati. They made frequent field trips together, principally investigating grasses and sedges. Riddell wrote letters of introduction for Frank to Torrey and Short. Frank was apparenly impressed with Riddell, for he named *Solidago Riddellii* as a tribute to him.

Riddell designed and constructed a microgasometer (1834), an instrument to analyze small amounts of gases. He also modified the ordinary thermometer in an attempt to increase its accuracy. He constructed an "odometer" of unknown use and value.

Riddell was awarded the degree of Doctor of Medicine by the Ohio Reformed Medical College on April 1, 1834, following an oral examination by Drs. Morrow and Jones. His diploma was signed by these men. It was customary for three signatures to appear — Riddell's own being the third, so, to make the document a little more legal Riddell asked Mr. Paddock, his successor as lecturer at Worthington, to sign the diploma.

VIII. THE BENNETT INCIDENT 1832-1834

At frequent intervals, beginning with his stay in Wheeling, West Virginia until April, 1834, correspondence and negotiations with Dr. John Cook Bennett took up a large amount of Riddell's spare time. Bennett promised him

> "the honours of a professor of chemistry and botany. . ."
>
> *Personal Journal,* vol. 7

in a newly established college, the University of Indiana at New Albany, Indiana, sometimes referred to as the Medical College of Indiana. In addition to the professorship Riddell was to be the recipient of an honorary degree of Doctor of Medicine. Later Bennett offered him a professorship at

Western Reserve College. Bennett was an impostor, but it took Riddell some two years to find it out. The scheme was such a bold one and was carried so far that a few paragraphs should be devoted to it.

John Cook Bennett was president of Christian College and of the Medical College of Indiana, as well as one of the secretaries of the Corporation and Bishop. The Christian College was chartered to grant degrees in Arts and Sciences, Law and Medicine, as well as the degrees of Doctor of English Literature, Doctor of Languages, Doctor of Mathematics, Doctor of Natural Science, Doctor of Belles Letters [note the peculiar spelling combination], Doctor of Arts and Sciences, and Master of Arts. A "Female Department" was provided for – an idea of Riddell's – offering the degrees of Doctress of Natural Science, Doctress of English Literature, Doctress of Fine Arts, and Doctress of Arts and Sciences.

Bennett sent Riddell clippings of newspapers showing the passage of the Act of the Indiana Legislature, January 24, 1833, creating Christian College and the Medical College of Indiana. The clippings contained the By-Laws of the College and a list of its faculty. Riddell was listed incorrectly as "James Lundsford Riddell." Along with Riddell on the faculty of the Medical College were Isaac Hough, professor of anatomy, physiology, and surgery; Chauncey Fitch Perkins, professor of the institutes of theory and practice of medicine, medical jurisprudence, materia medica, and pharmacy; and, John Cook Bennett, professor of midwifery and diseases of women and children.

Bennett even went so far as to announce a date on which Riddell would begin lecturing – the first Monday in November, 1833. When pressed by Riddell for details concerning the new post, Bennett was always evasive. But when Bennett began to ask him for money Riddell became wary and disgusted. Riddell traveled to Bloomfield, Ohio, to meet Bennett and make final arrangements, but Bennett failed to appear. That convinced him that the whole situation was a fraud, and prompted him to send letters of complaint to the Speaker of the House of the State of Indiana, and to the *Morning Courier and New York Enquirer,* published in New York City.

In these complaints Riddell protested the issuance of degrees with his name signed as "Registrar and Bursar" of the University of Indiana at New Albany, and an honorary degree of Doctor of Laws (not Doctor of Medicine) attached. His letter to the New York paper was published as an advertisement:

> "I learn that diplomas have been vended to or conferred upon, individuals residing in the City of New York, and various parts of the State, the same purporting to issue from the University of Indiana, at New Albany, and bearing my name, with an honorary degree appended, as "Registrar and Bursar" of that University. Now, sir, I deem it justice to community and myself to make it known that the whole has been done without my knowledge or consent; that I was not apprized of any appointment to those offices, and that I disclaim the honorary degree alluded to."
>
> *Morning Courier and New York Enquirer,* January 14, 1834, in *Repository,* vol. 6

Riddell won his point, for a few days later the Medical Society of the City and County of New York expressed its disapproval of the situation and called the degrees fakes.

IX. CINCINNATI – 1834-1836

On April 2, 1834 Riddell set out for Cincinnati, journeying first to Columbus, then by boat to Circleville, then to Portsmouth and Cincinnati. He listed his baggage as follows: three trunks, one chest, one tub, four boxes, and one bag. This was actually all of his worldly goods, except for several boxes of specimens stored at the family home in Preston. Of these items only one was for clothing, the rest for apparatus, herbaria, books, mineral specimens, etc. The *Journal* gives a summary of the contents of each. En route to Cincinnati, he took time to examine the mounds at Circleville, visited friends at other stops, and took notes on the geology of the regions he passed through.

He arrived in Cincinnati on April 6, and checked in at the Broadway Hotel. This was too expensive for him, and the next day he moved to Mrs. Thorpe's boarding house on Broadway and Sixth St. He paid $2.50 per week, but had to

> "furnish my own washing, fuel and lights."
>
> "Our fare is plain and wholesome, doubtless as sumptuous as health requires."
>
> *Personal Journal,* vol. 11

His first call was at the office of Dr. Daniel Drake, publisher of the *Western Journal of the Medical and Physical Sciences.* He had letters of introduction to Drake, and was well received. Riddell had previously sent him one of his publications and a "suit" or collection of plants. Drake inquired whether or not Riddell was a Doctor of Medicine. Riddell replied that he was not, and later scratched out "M.D." from his open letters of introduction. He visited Drake periodically, but apparently too frequently for Drake's liking. After a short time Drake's reception of Riddell ceased to be friendly.

Riddell also introduced himself to Dr. John Locke, who was to play an important role in his future. Locke was a scientist of sorts, interested in botany and natural philosophy, and the proprietor of a "female seminary." Locke had some apparatus for demonstrating electromagnetic phenomena, and had designed a new type of galvanometer, both of which he demonstrated for Riddell. But he was unable to convince Riddell that his ideas on the cause of attraction of "dissimilar electricities" were sound. Locke's ideas are quoted in Riddell's *Journal,* but are followed by comments of disapproval.

Another of his early contacts was Dr. T. D. Mitchell of the Medical College of Ohio. Mitchell encouraged him to complete his medical studies, but indicated that since his work at Worthington was not recognized, he must attend two courses of lectures. This discouraged Riddell, because he had hoped for a quick degree. Mitchell was also very pessimistic about Riddell's giving a series of botany lectures, saying that others had failed in a similar attempt.

The initial routine in Cincinnati consisted of making acquaintances, reading, and trying to launch a subscription for his lecture series. Most of the first month was spent in preparing an "Essay on Practical Botany," giving directions for preserving plants. To further his own collecting, he purchased a new press for drying plants. The essay did not interest the local booksellers or printers, so he turned his attention to a paper on barometer modifications. The paper described a right-angled barometer, the mercury column being both horizontal and vertical, so that small changes in the vertical would produce large changes in the horizontal. Tubes of different diameters were used. The paper was published in the *American Journal of Science and Arts* [Silliman's *Journal*] (see figure 3, p. 9).

> "The design of this contrivance is to render the indications of the barometer more obvious and delicate."
>
> *Am. Journ. Sci. and Arts,* 1835, vol. 27, pp. 223-224

At this time Riddell was quite discouraged. He felt that he was making no progress. He had

> "no real friends and very few acquaintances . . . I wish I were in Chenango Co., N.Y., but I have not yet met with success enough to return with a good grace. I must brave it out a while, I think."
>
> *Personal Journal,* vol. 11

But his life was far from dull. He attended teas and sewing parties, called on many people, went on visits to gardens and on botanizing expeditions with prominent citizens, but was never really accepted as part of the community. He was almost ready to abandon his plans,

> "If I do not get a situation to suit me and which has a fair prospect of permanence, and that too in less than three months, I am resolved on settling some where in the practice of medicine. I am determined if life and health are spared, to become settled some where."
>
> *Personal Journal,* vol. 11

The eccentric scientist was still concerned about the welfare of his mother and family. From letters received he had learned that they had moved to a house on a nearby farm, the Hancox place, for

> "$10 a year for house, garden and the use of a crib."
>
> *Personal Journal,* vol. 11

His mother was doing most of the farming, with the assistance of brother George. His brother Samuel was living with his sister and her husband, and learning blacksmithing. He

wrote to his mother to tell Samuel

> ". . . not to seek the bad company of wild and reckless boys, and by all means to abstain from little petty thievery."
>
> *Personal Journal,* vol. 11

Perhaps this last warning was a reminder of his own adolescent years.

The botany lecture series, given in the meeting room of the Cincinnati Medical Society, proved to be only moderately popular, and did not furnish enough money for him to live on, as he had expected. Of necessity Riddell was forced to solicit subscriptions for herbaria, a task which greatly annoyed him. He felt that this activity would lower him in the estimation of fellow scientists, but it provided, throughout the next year or so, the bulk of his income.

On May 8, 1834, Riddell lectured at the Mechanics Institute "On the Methods of Forming Herbaria and on the Affinities of Plants, Illustrated by a Beautiful Exhibition of Specimens, Taken Mostly from the Forest and Prairies of Ohio."

In the course of his social life he visited Harriet Beecher, the authoress, at her home, and called on Nicholas Longworth, vine grower and horticulturist, several times. His subsequent relationships with Longworth (1836) were not too cordial. Riddell also records a visit to Daniel Gano's garden on May 22, 1834. Gano was one of the subscribers for his lecture series, also one of the purchasers of a herbarium. It was from Gano's great-great-niece that some of Riddell's original specimens came into the possession of the Lloyd Library and Museum of Cincinnati, Ohio. These specimens, and others in the British Museum of Natural History, the Academy of Natural Sciences, Philadelphia, Pennsylvania, the New York Botanical Garden, the Gray Herbarium of Harvard University and the Department of Biology, Tulane University, are the only ones extant, so far as is known.

Riddell asked Dr. Drake and others to recommend him for a professorship of chemistry at the Louisville Medical College. Drake wrote to Dr. Joseph N. McDowell on June 13, 1834, stating that

> "He (Riddell) has delivered several courses of lectures on chemistry with approbation. His talents are respectable; his personal appearance fine; his manner remarkably modest and unobtrusive. . ."
>
> *Personal Journal,* vol. 11

These remarks do not quite fit subsequent actions. Several weeks later Drake's son told Riddell that his father had received a letter from Louisville from McDowell for Riddell. When Riddell asked Drake Sr. for it, he denied that any letter had arrived, and never did produce it. Riddell could not understand Drake's actions, unless, as he surmised, Drake was annoyed at the contents and wanted McDowell to write another less favorable.

It was at this time that Riddell learned of Dr. Josiah Hale of Alexandria, Louisiana. Dr. Hale was an accomplished botanist, so Riddell sent him one of his pamphlets. Hale later called on Riddell in New Orleans, Louisiana, (June 8, 1838) and the two became fast friends, and also were associates in the New Orleans Academy of Sciences (1853). Hale was buried in Riddell's tomb in the Protestant [Girod Street] Cemetery, New Orleans, Louisiana.

During the summer of 1834, Riddell went on a botanizing expedition through the Miami country, visiting Hamilton, Oxford, Middletown, and Dayton. He was well received at Miami University, where the president contracted for a herbarium and asked him to return to lecture on botany for several weeks during the regular session. We do not know that he did so.

The following winter Riddell studied at the Medical College of Ohio, lecturing occasionally, collecting and selling plants, and writing. His *Repository* contains his notes of lectures in surgery by Dr. Trauth, on practice by Dr. John Eberle, on materia medica and operative surgery by Dr. Smith, and others. He assisted Dr. James B. Rogers in the chemistry lectures, with little or no remuneration.

Riddell was living at the Commercial Hospital with his friend Dr. Otho M. Herron. Riddell and Herron were good friends and business partners. The exact nature of their business agreement is not clear, but Herron was a shareholder in Riddell's herbarium and plant collecting enterprises. Riddell suspect-

ed that this led to a distinct coolness between them. He moved to a new room, near the corner of Walnut and Fourth Streets, for $5.00 per month. He took his tea or supper at the Pearl Street House, and lived on bread and milk for the rest of the day. Riddell and Herron retained their friendship, and some months later they were together again at the Commercial Hospital. In 1836, Herron was instrumental in arranging Riddell's marriage.

Riddell was elected a junior member of the Medical Society of Cincinnati and later (1835) was chosen as the curator of the cabinet of minerals. He was still not a fully accepted member of the Cincinnati group, for he was not included in Dr. Drake's parties, nor was he introduced to the ladies of the Drake family. He did attend the Swedenborgian Church regularly.

Perhaps the most interesting experience during the winter of 1834-1835 was his participation, as an assistant, in a balloon ascension. A Mr. T. Kirkby had arranged with Riddell to ascend in a balloon, with Riddell making scientific observations during the flight. The proposed ascension received good publicity in the *Daily Gazette* and the *Republican.* Since the balloon was unable to support both men, Riddell was forced to remain on the ground. The *Republican* noted that the

> "extensive preparations which the doctor had made for scientific experiments and observation, added to his undoubted capacity and praiseworthy enthusiasm, would have rendered his excursion valuable to science and could not have failed to result in various discourses of a rare and interesting nature."
>
> *Personal Journal,* vol. 12

It is worth recording that one of the preparations made by Riddell was the drawing of a will, parts of which (perhaps all) he noted in his *Journal,* appointing Dr. Herron as executor and leaving all of his property to his family.

Riddell's "Geology of Ohio" was published by Dr. Daniel Drake in the *Western Journal of the Medical and Physical Sciences* in 1833. The work impressed Drake so favorably that he added his own comments to it. The same paper was printed in the Cincinnati *Chronicle* on February 15, 1834.

A short paper "On the vegetable origin of coal" appeared in the Cincinnati *Mirror* on January 17, 1835. This was Riddell's reply to a series of lectures by a Dr. Powell with whom he did not agree. The "Geological Features of Ohio" appeared in the Newark *Gazette* on April 13, 1836, and "Remarks on the geological features of Ohio" in the *Western Monthly Magazine* in March, 1836.

The "Geological ramble on the western reserve," an account of Riddell's expeditions in and around Cleveland, Ohio, in 1835, were published a year later. The work is less technical than the previous ones, containing more descriptive material.

Riddell lectured at the Mechanics Institute on "Electricity, Meteors and Clouds" on February 14, 1835, and on the "Penetrativeness of Fluids" on March 14, 1835. This lecture was published in the *Western Medical Gazette.*

One of Riddell's favorite subjects — permeation or permeability of membranes — was the topic of his lecture before the Cincinnati Medical Society, April 2, 1835:

> "On corpuscular permeation and the attendant phenomena with applications to physiology."

This subject always evoked much discussion, greatly pleasing Riddell, except when he was unable to convince his opponents. He believed that

> "permeation is controlled by the relative nature of the liquid and the membrane or medium."
>
> *Repository,* vol. 6

He also recognized that

> "if a membrane or tissue will tolerate the infiltration of a liquid solution, the permeation will proceed more rapidly in proportion as the solution is less dense; and most rapidly when the menstrum or solvent liquid alone is used."
>
> *Repository,* vol. 6

In his simplest experiment be used a small vessel completely filled with alcohol, and tied a piece of bladder over the open end, and then placed the vessel in a large container of water. The bladder surface was initially plane, but under water

> "now presents a very prominent convexity (endosmosis). If the experiment is repeated

with water in the small vessel and alcohol in the larger vessel, concavity (exosmosis)."

Repository, vol. 6

Riddell also set up a series of experiments analogous to Graham's diffusion experiments, using powdered emery, powdered glass and insoluble precipitates to test capillarity and permeation. In discussions he chose his illustrations from nature – fungi, lichens, algae, the glands and the liver.

During the winter of 1834-1835 he had not heard from Catherine Burr, nor had he written to her. He had indirect knowledge of her from friends, and when he was told that she was

"rather worsted in appearance. . ."

Personal Journal, vol. 13

by illness, he concluded that she was suffering from consumption. When he did write to her he stated:

"I deeply regret that my worldly condition does not warrant me in making such immediate proposals as my feelings dictate."

Personal Journal, vol. 13

In one of his periodic letters to his mother he gave full directions for his brother Samuel to come to Cincinnati to join him, and to help him with his collecting of plants and preparations of herbaria. If Samuel did not want to make the journey, his mother was urged to send his brother George. For three months he expected Samuel, but Samuel did not appear. His mother wrote that he had left Preston on May 8, 1835, and no one had heard from him or of him in September. The *Journal* contains frequent references to this situation, for John Leonard wanted Samuel to assist him on his summer field trip, but there was no Samuel. The elder brother was somewhat worried, and greatly irritated by his younger brother's conduct.

During the summer of 1835, Riddell and his friend A. O. Lindsley traveled most of the state of Ohio on a botanizing and geological expedition. They were business partners in the sale of herbaria. From Cincinnati they traveled to Portsmouth, then to Chillicothe. At Portsmouth, Riddell found

"plants he had never seen before, none of them not hitherto accredited to the Western States,"

Personal Journal, vol. 13

and was also quite ill with cholera. The partners had little success with their subscriptions in Chillicothe, and likewise little success botanizing, for Riddell complained that the sheep and cattle had ruined the flowers and herbs.

From Chillicothe they traveled to Columbus and called on old friends there, particularly Increase A. Lapham, secretary of the Historical and Philosophical Society, and on Dr. Ichabod G. Jones, one of Riddell's instructors at Worthington. While in Columbus he learned that a Mr. Acheson, a slight acquaintance from Wheeling, and a friend of his former landlord King, was in town. This information produced the remark

"I should like to see the Acheson faithfully plastered in mud, with a special reference to his shameful behaviour to myself."

Personal Journal, vol. 13

What provoked this language is not clear, but was probably part of the Wheeling incident.

Riddell traveled from Columbus to Hebron to Mount Vernon, where he visited Catherine Burr at her brother's home. Catherine was not as ardent as before, but they did travel to Gambier together, rambled in the woods and attended church. When they parted, for the last time, on July 9, 1835, Catherine, at his request, gave him a lock of her hair, which is now in the Archives of the Howard-Tilton Memorial Library of Tulane University, New Orleans, Louisiana.

In spite of the fact that his old feelings for Catherine were aroused again, he wrote

"I have once more become rather convinced that circumstances will for some years perhaps prevent my forming any matrimonial agreement. I am the oldest child of my dead father's destitute family. A great responsibility rests on me."

Personal Journal, vol. 13

From Mount Vernon to Webbsport to Zanesville, back to Webbsport, then to Coshocton, Roscoe, Dover, Massillon, Akron, and Cleveland was the route taken by the two solicitors. There was not too much success in Zanesville, for the citizens were too poor to patronize a botanical project, and little profit was left when they reached Cleveland. Riddell was ill with intermittent fever in Dover, and again in Cleveland.

On August 17, 1835, Riddell lectured in the Courthouse in Cleveland "to a respectable audience" on the "Forming of Herbaria" and illustrated the address with an exhibit of specimens. There were no subscriptions forthcoming.

He remained in Cleveland for some time, taking many side trips or "rambles" to the surrounding countryside. Some of these are summarized in his paper "A Geological Ramble." There was still no word from Brother Samuel, so John Leonard inserted an advertisement in the *Daily Cleveland Herald,* on August 25, 1835, as follows:

> "Samuel T. Riddell left his mother's residence in Preston, Chenango County, New York, on the 8th of last May, with the intention of visiting the subscriber in Cincinnati. He was expected to go by stage to Syracuse, thence by canal to Buffalo, to cross the lake to Cleveland, and to follow the canal and the Ohio River to Cincinnati. He is 16 years of age, 5 ft 8 inches in height, rather slim, with light brown hair, full face and fair complexion; the little finger has been cut from his right hand. His clothing was a fur cap lined with blue silk, coat and pantaloons of blue broadcloth, with yellow metal buttons on the coat, blue and white vest and calf skin boots. He has not been heard from since he left, and as there is reason to believe some misfortune has befallen him, his friends are extremely anxious to ascertain what has become of him.
>
> "Editors of newspapers on the New York and Ohio canals are requested to insert this. Any relevant information will be thankfully received if addressed to the subscriber at Cincinnati or Mrs. Lephe Riddell, Preston, Chenango County, New York."
>
> John L. Riddell
>
> *Personal Journal,* vol. 13

Riddell then took steerage passage on a lake vessel for Buffalo en route to his old home in Preston, New York. He was retracing Samuel's supposed route and inquiring on the way. He was ill with fever in Buffalo, and remained there a few weeks. Subscriptions in Buffalo were very good. From Buffalo he traveled to Syracuse and Rochester, then to Preston. He noted that his income for the summer was about $201.00, not all in cash. He had traded some plants for books and a watch, but had $175.00 in cash. En route, he visited his sister Mariah and her husband. Ruel Crumb, and his sister Lovina. Lovina accompanied him to Preston. While passing through Solon, New York, he recalled teaching there when he was seventeen years old, and remembered Sarah Ann Hawley.

He never did locate Samuel, but did find that he had worked for several months as a driver for the towing company on the Erie Canal. Riddell spent four days at home – a very short visit considering the distance he had come and the financial sacrifice. His brothers George (age 13), William (age 7) and his sister Susan (age 4) were at home with his mother. Like a dutiful elder brother he brought presents with him. As would be expected from a man of his disposition, John Leonard itemized each gift he presented.

> "To George: a toothbrush and a gold quarter eagle ($2.50).
> To William: half a dollar.
> To Lovina: silk pocket handkerchief and toothbrush.
> To Susan: a piece of calico worth 30¢ and a quarter of a dollar.
> I brought Mother: 2 bushels of cornmeal, $2; half a bushel of ground wheat, 75¢; half a bushel of turnips, 12¢; a penknife, 31¢; paper, 6¢; half a set of knives and forks, 41¢; 12 pounds of nails, 96¢; tea, 25¢."
>
> *Personal Journal,* vol. 13

He also left $30.00 with his mother for repairs on the house and cellar, and for the purchase of firewood for the winter. While at home, he visited with Randolph Williams and other old friends, and discussed his mother's financial condition at length, itemizing the existing family debts. His mother's relatives were still holding a note against his father's estate for about $40.00, given for the purchase of a horse before John Leonard was born.

On his return to Cincinnati he stopped in Norwich and paid all debts that he had incurred when he taught there in 1830. His mother wanted him to take some of the family possessions with him, but he accepted only a handmade coverlet as a keepsake. He returned by the same route and arrived in Cincinnati on October 30, 1835.

As Riddell had foreseen, there was an internal feud in the Medical College of Ohio. Dr. Daniel Drake took advantage of this, and established the Medical Department of Cincinnati College, on June 27, 1835. He

served as dean and professor of the theory and practice of medicine; and his associates were Dr. Joseph N. McDowell, special and surgical anatomy; Dr. Samuel D. Gross, general and pathological anatomy, physiology and medical jurisprudence; Dr. Horatio Jameson, surgery; Dr. Landon C. Rives, obstetrics and diseases peculiar to women and children; Dr. John P. Harrison, materia medica, and Dr. James B. Rogers, chemistry and pharmacy. Riddell was listed as adjunct professor of chemistry and lecturer on botany. His lectures on botany were

> "strongly recommended by the Trustees and Faculty, but not requisite to graduation."
>
> *Repository,* vol. 7

Riddell assisted Dr. Rogers, held private classes in chemistry and botany, and attempted a special series on chemistry for young ladies.

His friendship with Dr. Herron had been resumed, for we find in the *Repository,* Volume 7, "Discussions, Physical and Metaphysical, between H and R," a few pages of miscellaneous questions and answers.

Riddell was still unmarried, and still very lonely, even though his mother had indicated she would favor his marriage. On November 1, 1835, Dr. William Byrd Powell of New Orleans, Louisiana met Riddell, and asked for his address. This puzzled Riddell, for he wrote

> "I cannot conceive what the Doct. would be at, unless it be to get me appointed Professor of Chemistry in the New Orleans Medical College, a place which he now holds himself."
>
> *Personal Journal,* vol. 14

This prediction was correct, but it was not until the summer of 1836 that the formal offer of the position was received and accepted.

Since his days at Worthington he was one of a small group urging the Legislature of Ohio to authorize a complete geological survey of the State. He was naturally thinking of a job for himself, and openly announced his candidacy for the post of State Geologist. In his opening message to the Legislature in the fall of 1835, Governor Robert Lucas asked for such a survey. The *Repository* contains many clippings indicating much pressure on the Legislature to carry out the Governor's request. It is certain that some of these were instigated by Riddell. In the spring of 1836 Dr. Samuel Prescott Hildreth, Dr. John Locke, Increase A. Lapham and John Leonard Riddell were appointed by the Legislature to make the plans for a complete survey of the state. The four were good friends, and Riddell did not object to the appointment of Dr. Hildreth as chairman. The committee agreed to split the state into four divisions, each member planning to work in his area for two months during the summer of 1836. They reported to the Governor and Legislature, but were not given the complete authority they requested. A new committee was formed, consisting of the same four men, and W. W. Mather, Dr. Jared Potter Kirtland, Charles Whittlesey, Caleb Briggs and J.W. Foster. They were charged with studying the

> "topography, relationship of rock strata, extent of ore beds, etc. marl, iron ore, value of ores. . ."
>
> *Personal Journal,* vol. 14

Lapham was unable to participate, so Riddell volunteered to do Lapham's portion of the survey as well as his own. In 1837, Riddell submitted his portion of the survey to the new governor, Joseph Vance. His material, a compilation of all of his Ohio explorations was appended to the "Geological Survey" when it was issued by the state printer J.B. Gardiner, in Columbus, Ohio, in 1837.

Riddell was still much concerned about his family, but was now able to send his mother an occasional ten or twenty dollar bill. In each case he noted carefully the denomination and number of the bill, and the bank of issuance.

On January 27, 1836, Riddell noted that he was finally out of debt, and had enough money

> "to meet my contingent and unavoidable expenses probably for some time."
>
> *Personal Journal,* vol. 14

This was really the first time in his entire life that he did not express worry about his financial condition.

Riddell completed his work for the degree of Doctor of Medicine and was gradu-

ated on March 5, 1836, writing his thesis on the nature of contagions and miasmata. The thesis was very well done, and was presented to the Cincinnati Medical Society in a lecture on February 3, 1836. Riddell's interest in contagions stemmed from his days at Worthington, for he had lectured there on the animalcular theory of contagious infections (January 9, 1834). At the meeting of the Medical Society, there was the usual argument against his theory, but Dr. Daniel Drake came out in Riddell's defense, adding his strength and prestige to the theory. Riddell's principal point was that contagious diseases must be caused by organic, living things. Riddell was far ahead of his times in his reasoning, and this paper was one of his major accomplishments.

On March 16, 1836, Riddell presented his "Synopsis of the Flora of the Western States" and his supplement, with exhibits, before the Western Academy of Natural Sciences, of which he had been chosen a member. He was also honored with corresponding membership in the Maryland Academy of Sciences and Literature.

"The Supplementary Catalog of Ohio plants" appeared in the *Western Journal of the Medical and Physical Sciences* in 1836. This contained seven new species, of which four are still credited to Riddell:

Linum sulcatum
Scutellaria saxatalis
Stachys cordata
Helianthus occidentalis

An attempt to simplify the nomenclature of organic chemistry was published in the *Western Journal of the Medical and Physical Sciences* in 1836. Riddell devised various abbreviations in a rather futile attempt at simplification. The use of the following symbols was advocated:

oxygen	o	d	1	z	9
hydrogen	e	1	2	i	10
nitrogen	a	r	3	ii	100
carbon	u	m	4		

There were two basic rules in Riddell's system:

> "Rule 1. In the formation of a name, those mineral and elementary symbols referring to each other are placed side by side, the former on the left hand, the latter on the right.
>
> "Rule 2. When a mineral consonant occurs on the left hand of the mineral vowel i, the two letters are factors; they are to be multiplied together. When the consonant occurs on the right hand, its value is to be added to that of the vowel.
>
> "Examples: mi . . . 40; im . . . 14;
> mm . . . 44; tip . . . 86.
>
> "Note: The letter d when a factor may either be prefixed or omitted as the harmony of the syllables require."

Characteristic illustrations of this mnemonic nomenclature are:

oxalic acid	luro
mellitic acid	muro
amylic acid	vupo
acetic acid	remuro
lactic acid	mepumo
citric acid	mulemo
uric acid	lavulero
oil of cloves	voireliu
olive oil	ronieviru
cane sugar	tozute
caffein	lotuvela
urea	ruperora
water	ode
nitric acid	avo
alcohol	orelu
ether	ovemu
morphia	porimuitea
codeia	voriulidea

West. Journ. Med. and Phys. Sci., 1836, vol. 9, pp. 687-690.

Riddell divided organic compounds into four classes: acids, vegetable alkalies, inflammables and neutral bodies, as noted from the illustrations above. His method is far from simple, and did nothing to further his aims. His notebooks contain only a few references to his own use of symbolism in this field.

On one of his visits to Dr. John Locke he

> "saw a tall, dark-eyed lassy belonging to his school, from the 'low country' . . . we often saw each other with none present but the Doctor's children, who are little boys."
>
> *Personal Journal,* vol. 14

Here began a serious romance. Mary Elizabeth Knocke, or Mary Bone, or Mary Schrager (all three names were used initially) was immediately captivated by Riddell. She was an orphan from New Orleans, Louisiana and knew little of her background. John Leonard became more and more interested, and wished for additional information about her family and financial condition.

During his Worthington stay Riddell had met Colonel George William Boyd of New Orleans. Boyd was much impressed with Riddell's lecturing and with his herbaria. He had corresponded with Riddell, so the young doctor wrote a letter requesting Boyd

> "to apprise me if the chair of chemistry in the New Orleans Medical College becomes vacant . . . that if I do not see a prospect of promotion here I would have no objection to spending my winters there. . ."
>
> *Personal Journal,* vol. 14

He told Boyd about his meetings with Mary, and asked him to find out all he could about her uncle, Jacob Schrager, and her guardian D. F. Burth.

> "Now, if this orphan girl, for whose welfare I feel a deep interest, being of respectable parentage, has enough of this world's riches to enable me to support her in the quiet station we should aim to occupy, Heaven permitting, I am resolved to make a wife of her."
>
> *Personal Journal,* vol. 14

Riddell realized that his friendship with Mary would antagonize Dr. Locke, but he was determined to woo her in spite of this. On his twenty-ninth birthday he wrote wistfully:

> "Ah, me, time I had a wife . . . I cannot deny that my Creole Mary of the female seminary frequently engrosses my thoughts . . . she hath no careful mother to tell her not to engage in flirtations—but, not overstepping the bounds of modesty, she acteth up to the promptings of her warm feelings, and I love her for it."
>
> *Personal Journal,* vol. 14

While carrying on his courtship of Mary he was linked romantically with Eveline, a nurse and servant girl at Dr. McDowell's home. The intrigue was all Eveline's — she wanted to marry him but he spurned her — so Eveline created some scandalous stories about Riddell and circulated them. These did not help his reputation with his fellow faculty members in the Medical Department.

Since the Lockes did not approve of any of the students receiving callers, Riddell's meetings with Mary were in secret. Locke's young son, John, served as intermediary, transmitting letters and packages, but the boy soon turned against them. Meetings were then confined to public streets, where they would walk together, or occasionally go riding. One Sunday evening Mary came to his room in disguise.

> "She remained three hours during which time many pleasant sayings and doings were exchanged, but nothing I presume which her mother would have found fault with, unless she would object to her daughter's being kissed while lying on the sofa . . . I convinced her that I was accomplished in the famous art of kissing."
>
> *Personal Journal,* vol. 14

The pseudo-affair with Eveline came to the attention of the Lockes, who tried to turn Mary against him. He wrote to Mrs. Locke that his intentions were honorable, and that he planned to marry Mary. Mrs. Locke turned his letter over to her uncle, Nicholas Longworth, giving it a most improper interpretation. Longworth was set to "expose" Riddell, but was prevailed upon by mutual friends not to do so. Riddell wrote a letter to Longworth explaining the entire situation, but did not receive a reply. Dr. Herron and other friends were urging him to marry immediately, but there were legal entanglements because of the fact that Mary was an orphan. Marriage in Indiana was suggested, but did not prove feasible.

On June 19 he had definitely decided to elope the next day. He was planning to be away from Cincinnati on the geological survey for several months, and decided that Mary should go with him. The marriage was arranged by Dr. Herron, Dr. Morgan and Esq. Fobes. These three men took Mary and John Leonard to Newport, Kentucky on June 20, 1836, where arrangements had been made at Baxter's Tavern. Dr. Herron was called upon to swear that

> "the young lady's former guardian, Mr. Burth, was much gratified with preference which I (Riddell) had given her."
>
> *Personal Journal,* vol. 15

The marriage was performed by Rev. Mr. Southgate between eight and nine in the evening. The ceremony was witnessed by Mr. Pendleton, Clerk of Court, the three Cincinnati friends, Mr. Baxter and several others. Dr. Herron was the best man. The group returned to Cincinnati for a wedding supper at the home of Esq. Fobes. John Leonard and his bride left the next morning on their summer explorations.

At their first stop Riddell wrote an explanatory letter to Mr. John W. Holland of New Orleans, Louisiana, Mary's present guardian. Holland replied promptly, extending good wishes, whereupon Riddell wrote a letter of inquiry concerning Mary's financial condition. This matter was not completely cleared until much later when they went to New Orleans to live.

The young couple traveled from Cincinnati to Pleasant Ridge, Clarksville, Yellow Springs, Springfield, West Liberty, Sandusky, Springville and Wooster. Riddell examined geological formations, analyzed mineral springs and water, studied the flora, and interviewed many of the farmers and townspeople about the mineral wealth of the regions. These details he recorded with care. This information, and that collected the previous summer, furnished the bulk of his report to the Governor of Ohio. The material was actually sent from New Orleans to Governor Joseph Vance on January 12, 1837, and is thirty pages in print.

Riddell was tempted to purchase 120 acres near Springville, Ohio. The land contained springs with a high concentration of magnesium sulphate, and Riddell contemplated manufacturing laxative salts from the water.

The return of the young people to Cincinnati in August, 1836, was not a happy one. The wives and daughters of Dr. Locke's associates and many of Riddell's friends would have nothing to do with Mary because

> "she came to my room before we were married."
>
> *Personal Journal,* vol. 15

Part of this confusion was caused by Eveline, who continued to spread stories. Mary knew all about Eveline, and the reasons behind the actions of the ladies of Cincinnati.

X. NEW ORLEANS – 1836-1840

In October, 1836, we find the Riddells en route to New Orleans, Louisiana on the steamboat *Gazelle.* Dr. Riddell has been offered the professorship of chemistry at the New Orleans Medical College, as he termed it, replacing Dr. William Byrd Powell, resigned. The correct name of the institution was the Medical College of Louisiana. His formal acceptance was written to Dr. Edward Hall Barton, the dean of the College, on November 2, 1836. On their arrival in New Orleans the Riddells resided temporarily on the southwest corner of Canal and St. Charles Streets, and later moved to their own home at Camp and Bartholomew, No. 328 Camp Street.

Riddell's initial appointment was as professor of chemistry. For 1838-1839 the appointment was as professor of chemistry and pharmacy. He was also co-professor of materia medica, therapeutics and hygiene during part of 1839, in addition to his duties in chemistry.

One of the first things Riddell did in New Orleans was to investigate the status of Mary's property. It was necessary to arrange for Mary's emancipation, which was done with the assistance of Colonel George William Boyd and of Judge Charles Tessier of Baton Rouge, Louisiana. Mary's father, Ludovic Knocke, had been murdered in Baton Rouge about 1825. He owned some land and two houses, had about $1000 in cash at the time of his death, and was also a partner in a "teaching establishment." Mary's uncle, Jacob Schrager, died in 1832. As the years passed Riddell's management of Mary's property was most successful, so that their financial worries were over.

The first child of Mary and John Leonard was born April 2, 1837, John Schrager Riddell. The boy died on June 6, 1837. A second son, Sanford Schrager Riddell, was born August 22, 1838. Mary was not well for some time afterward, and early in 1839 Mrs. Lephe Riddell, John Leonard's mother, and his sister Susan came to New Orleans to live with him and to help with the baby.

Riddell maintained an extensive correspondence with scientists during most of his New Orleans life. Some of these letters give us an indication of his activities, such as the following one, addressed to Robert Buchanan, commission merchant of Cincinnati, Ohio:

> "I sent you a package of plants and letter by the S. boat Independence about a month ago; . . . I hope you have received them. I have requested the Secretary of Gov. Vance

(Mr. E. F. Drake) to send me through you a number of copies of my geological report . . . Is poor Herron living? You know he was physician to the hospital and lately staid with Mr. DeCharnes. I sent Herron a draft for $60 at the time I sent your package, on the house of McClellan and Yorke "payable to his order only." I should like to know whether it had been presented for payment.

"I left in the care of Dr. J. B. Rogers of the Medical College, 5 boxes of minerals, fossils, etc. They were placed underneath the seats in the chemical lecture room.

Box no. 1. Eastern minerals
2. Eastern minerals
3. Wooster fossils from Dr. Bissell
4. Collected in Ohio in 1836
5. Western specimens

Weight of all perhaps 4 or 5 hundred pounds. I will thank you to send all the boxes to Yorke Brothers, where I will pay charges.

"I spend my time now in botanizing and in writing a monograph of the ligneous plants of Ohio, classified and distinguished from leaves alone. I design to have a wood cut of every leaf. It may extend to 300 printed pages. If the Western Academy was sufficiently in funds and so disposed I would offer it for publication. I design it more for the general reader than for the professed botanist. . .

"We have a stout healthy son three weeks old; — my wife enjoys her accustomed health and strength, sends her love to Elizabeth."

J. L. Riddell to Robert Buchanan, April 25, 1837. Letter in Simon Gratz Collection, Historical Society of Pennsylvania

In a letter to his old professor, Amos Eaton:

"As a small token of my unabated esteem, I have sent you to the care of Dr. Torrey of New York, a package of Louisiana plants, gathered mostly during the last summer. Of the new ones I have sent specimens with full descriptions for insertion in Torrey's *Flora of North America.* If you should publish another edition of the Manual before the completion of his work, I will, if you wish it, prepare . . . descriptions of new and little known Louisiana plants, in accordance with the general plan of your work, and forward the same to you by any time you may designate. . .

"I publish nothing now-a-days, not because I am idle, but because it costs nearly three times as much money here as at Philadelphia to procure printing."

J. L. Riddell to Prof. Amos Eaton, November 10, 1838. Letter in the Albany Museum Archives, State Museum, Albany, N.Y.

Riddell, naturally, was active in scientific and in political circles in New Orleans. In July, 1837, he devised a set of abbreviations for recording the steps and results of procedures in qualitative analysis. The symbols and characters resemble a shorthand. His *Journal* gives a lignite analysis and a mineral water analysis in terms of these symbols. They seem to us today to be completely useless.

After he was firmly established at the Medical College of Louisiana Riddell resumed his collecting and exchanging of plants, and in 1838 discovered a

"new and remarkable species of *Asclepias.*"

Personal Journal, vol. 17

dedicating it to Dr. Daniel Drake, *Asclepias Drakeana.*

He noted in his *Journal* on July 3, 1838

"I am about publishing a book on the botany of Louisiana."

Personal Journal, vol. 17

He envisioned a catalog containing plates of leaves lithographed by a special process. Riddell tried several methods, made plaster casts of leaves, and ended up with "phyllographic printing." His directions are as follows:

"Spread the upperside of a dry leaf with adhesive plaster by rubbing on a hot flat iron — or a hot flat iron on it — so as to imbue its whole substance therewith. Lay the upper surface on a dry, polished lithographic stone; lay clean bibulous paper over it and run over a hot flat iron, so as to cause it to adhere. Moisten the stone with a sponge and ink in the ordinary way. Print with a soft roller or downward direct pressure. It will be well to rub down the prominent veins with pumice stone and oil the surface with a hair pencil previous to printing."

Personal Journal, vol. 17

Samples of this method are given in his *Journal.* The book referred to was in preparation over ten years, and was the "Catalogus florae ludovicianae."

Riddell was very popular with his students, for several of his "introductory lectures" were published at the request of his students. But he was not certain that he wanted to remain in New Orleans. On one occasion he wrote to his mother that he still planned to return to Preston to practice

Figure 4. A page from Riddell's *Personal Journal* showing one of his illustrations of "phyllographic printing" (Howard-Tilton Memorial Library, Tulane University).

medicine. His feelings are also evident in a letter to Dr. Daniel Drake, June 6, 1838:

> "Though my prospects in a pecuniary point of view are fair enough here; yet the want of congenial society — I mean the entire want of associates in the prosecution of the natural sciences, causes me to think often of Cincinnati."
>
> *Personal Journal,* vol. 17

In his early years Riddell's scientific work had been concentrated in the fields of chemistry, botany, and geology. The investigations of his New Orleans period were primarily in the fields of natural philosophy (physics) and medicine. The fundamentals of mechanics were disturbing to him. He was not able to picture, to his own satisfaction, the constitution of matter. He was not able to explain collision processes. He did not agree with the Newtonian theory of gravitation. Most of his speculations dealt with attempts to answer these questions, culminating in his "Constitution of Matter" lecture and paper (1846).

In 1839, Riddell noted that his monograph on the "Ligneous plants indigenous to Ohio" was ready for distribution. The manuscript had been sent to the *Hesperian* in Columbus, Ohio, November 24, 1838.

In February, 1839, Riddell turned his attention to a program to secure authorization by the Legislature of the State of Louisiana for a geological survey. He memorialized the Legislature, and also wrote several articles for the bilingual French-English newspaper, *L'Abeille de la Nouvelle Orleans.*

From April 15, 1839, to May 24, 1839, Riddell visited Texas, going from New Orleans by sea. This was the first time that he was out of sight of land, and boasted that he was not seasick. The phosphorescence of the agitated sea water at night intrigued him. He records, unfortunately, that he was quite seasick before the voyage was over.

From September 15, 1839, to November 15, 1839, he was engaged in a geological field trip in Texas. The purpose of this expedition is given in the following extract, written at the time of Riddell's death. The date in the second paragraph, 1838, is incorrect, and should be 1839.

> "About this time (1837-1838. . .) much was said concerning certain mines of gold and silver in Texas, especially the "San Saba" which were said to have been worked at one time with great success by the Spaniards. Report further stated that, owing to the great severity of the Spaniards toward the Indians, whom they compelled to work these mines, a general massacre followed, in which every Spaniard perished; and further, that through fear of like abuses and through jealousy of their own rights in the matter, the Indians had ever since concealed as much as possible, and guarded with untiring vigilence against the approach of any whites. A company was formed to purchase and locate lands as near as possible to these mines.
>
> "In 1838 Dr. Riddell was engaged by this Company to explore this section of the country, and if possible find the true location of these mines. He spent three months in the wilds of Texas, in the service of the company. The party penetrated nearly to the supposed locality of the mines, but becoming more and more annoyed by the Comanche Indians, judged it hazardous to remain very long; it was in fact no easy matter to discover in so short a time, a mine, concerning which so many conflicting opinions were rife; yet the objects of the company were in part realized, since they had obtained the data from which to judge the general mineral character of the country. For this service he received one share in the rights of the company, equivalent to 10,000 acres of Texas lands."
>
> *The Daily Southern Star,* New Orleans, Louisiana, October 8, 1865

The Texas survey was quite extensive, and one complete volume of Riddell's *Journal* is devoted to the trip. His companion on the journey was fifteen year old Frederic Banks, his wife's cousin, then living with him. They did not make the entire trip alone, for in many places quite an assortment of military personnel accompanied them. The *Journal* account is filled with descriptions of formations, flora, Mexican food, bits of history, and details of their camp life.

"Observations on the geology of Trinity County, Texas" was published in the *American Journal of Science and Arts* in 1839. This is a detailed description of soil, rocks, springs and terrain of the territory covered. He gives the analyses of waters found in the mineral springs, and comments particularly on the brown coal or brown lignite deposits. In addition to these items he comments on the economic possibilities of the region. It was Riddell's idea that the city of Galveston, Texas, should become a coal market, and that the brown coal or lignite be used for fuel on ships. He also thought that Galveston should become an outlet for the export of salt obtained by evaporation of the waters of the nearby springs. Neither of these possibilities became a reality.

Riddell's wife Mary died of tuberculosis on December 20, 1839. Riddell was greatly affected, and wrote in his *Journal:*

> "She was kind, tractable and pleasant in her disposition, and devotedly affectionate. She was light and elegant in her form, handsome in her features, and highly accomplished in her education. True, as she married young and from a boarding school, she was less forward in fashionable society than many of less than half her worth, yet this retiring disposition of hers concentrated her whole feeling and attention at home, and served but to endear her the more to me. She is forever gone and I feel no disposition to let another usurp her place in my affections; neither under present circumstances would I wish to marry again although I could acquire wealth thereby. Therefore let my affections and energies hereafter, as before my marriage with Mary, be devoted to those natural sciences of which I am fond."
>
> *Personal Journal,* vol. 18

After Mary's death his mother took charge of the household. She immediately objected to a Dutch girl named Eliza, who was both chambermaid and nurse. Reluctantly Riddell consented to her dismissal.

On his return from the Texas ramble, Riddell received an appointment from President Martin Van Buren as melter and refiner at the United States Branch Mint in New Orleans. He held this position, in addition to his teaching duties at the Medical College of Louisiana, until 1848. He records the appointment:

> "Returning two weeks since I found that I had been honored with an appointment in the Mint, which alone while it may last, secures me all the independence in the way of wealth I desire."
>
> *Personal Journal,* vol. 18

He moved his family to the Mint shortly before Mary died. While this may have been beneficial to him financially, the new position was a source of serious trouble.

XI. THE NEW ORLEANS BRANCH MINT – 1839-1848

The United States Branch Mint at New Orleans was under the supervision of Joseph M. Kennedy. The principal members of the staff were H. C. Cammack, treasurer; Dr. William P. Hort, assayer; Philos B. Tyler, coiner; J. Bertrand, weighmaster, and Dr. John Leonard Riddell, melter and refiner. From various documents we learn that the Mint was not functioning properly prior to Riddell's appointment, that there were technical as well as political difficulties involved.

Riddell was inexperienced in metallurgy and was given meager directions for processing silver and gold. The first serious occurrence was on January 11, 1840, when there was a considerable loss of silver and gold when glass vessels burst while being heated on a flat, unprotected sand bath. Riddell did succeed in preparing silver ingots suitable for coinage, but had much difficulty with gold.

What we would now term labor troubles led to Riddell's second controversy at the Mint. He discharged two workmen, Peter I. Levick and Ewald Ernst, on the grounds that they were incompetent, but made the error of indicating that he wanted one of the positions for his brother George. Since his brother Samuel had been appointed foreman in the separating room at the Mint the question of family patronage naturally arose. Levick and Ernst appealed to R. M. Patterson, Director of the Mint in Philadelphia, Pennsylvania. Ernst accused Riddell of making a bargain with his workmen so that they would give up a portion of their wages to him. Superintendent Joseph M. Kennedy investigated the charge, and found it to be completely false.

The major incident arose from Riddell's failure to promote Dr. John McCarthy. McCarthy, an apothecary from Cork, Ireland, was a graduate of the Medical College of Louisiana, Class of 1839. Riddell hired him as a laborer in his department at the Mint. Why this was done, we do not know. After a few months McCarthy wanted a promotion, but Riddell did not think he deserved one. McCarthy began to

> "spread most slanderous falsehoods in relation to my official doings."
>
> *Personal Journal,* vol. 18

McCarthy left the Mint but continued to spread accusations against Riddell. He accused him publicly of default, incompetence, stealing and cowardice, and insinuated that he had murdered his wife. Riddell threatened legal action for slander, but the situation was too tense for that, with articles in some of the newspapers accusing Riddell. Riddell had his accounts checked and published the report of the Treasurer, who found everything in order. On the advice of friends, Riddell, his brother George and a workman in his department named Nixon, sought out McCarthy, and Riddell accordingly

> "chastized him on the piazza of his boarding house."
>
> *Personal Journal,* vol. 18

McCarthy promptly charged Riddell in Criminal Court with assault and battery. Riddell was convicted. McCarthy also brought a civil suit for damages. Judge Canonge of the Criminal Court assured Riddell that he would not be imprisoned but fined, since he felt Riddell was too valuable to the Mint to be jailed. Sentence was deferred pending conclusion of the civil action. Records on the final disposition of the case cannot be located.

All of these incidents reached Dr. R. M. Patterson, Secretary of the Treasury Levi Woodbury, and President Martin Van Buren. The exact charges which were made against Riddell were as follows:

> ". . . The President had directed a statement of the charges made against you to be transmitted to you for your explanation. They are as follows, viz:

"1. That you have unnecessarily quarrelled with and discharged your workmen — that you have lost the regard of your fellow officers and that you have not succeeded in preserving in the Mint the harmony and good feeling so much to be desired and without which the operations of the Mint must be retarded and the situation of the other officers rendered unpleasant.

"2. That you have given bad ingots to the Coiner and do not seem to be able to make them better.

"3. That the day after the examination of the contents of your Vault by the Treasurer, you went accompanied by your brother and one of your workmen to the lodging of Mr. McCarthy formerly one of your workmen, who had left the Mint, and whipped him very severely — that this transaction has brought disgrace upon the establishment and subjected you as well as those who accompanied you, to a criminal prosecution.

"Your early attention to such a course of explanation and refutation as these complaints seem to require, is desired. . ."

Levi Woodbury to J. L. Riddell,
June 24, 1840,
National Archives, Fiscal Section

The formal statement of these charges climaxed two months of internal feuding in the Mint. An exchange of letters between the superintendent of the New Orleans Branch Mint, Joseph M. Kennedy, and R. M. Patterson, the Director of the Mint in Philadelphia, Pennsylvania, and between Patterson and Levi Woodbury, Secretary of the Treasury, reveals much discontent and difficulty. The failure of the Mint to produce adequate gold coins from the gold supplied to it was the chief difficulty, and all of the personal antagonisms were related to this. The complete correspondence is given in the *Appendix*.

Riddell sought the origin of some of the charges, and found that Kennedy and the treasurer, Cammack, transmitted them to Dr. Patterson, although Kennedy denied it. On July 14, 1840, Riddell wrote a lengthy letter to Levi Woodbury in his own defense, taking each phrase of the charges and documenting his reply with letters. All of the officers of the Mint except the coiner, Tyler, came to Riddell's defense. Riddell and Tyler were having a running feud over the processing of gold ingots, for Tyler had rejected most of the gold submitted by Riddell. Riddell wanted to experiment with the method of preparing the ingots, and use some of Tyler's equipment, but was refused, time after time. The matter was finally submitted to Dr. Patterson, It was found that Riddell was not using the approved method for preparing the gold, that he had not been given the specifications which were sent from Philadelphia to New Orleans. Also it was found that Tyler was not completely correct in his methods, so that there was error on both sides.

The gold controversy was but a part of the larger group of charges. Patterson recommended to Woodbury, July 27, 1840, that the matter be dropped, even though he expressed violent disagreement with Riddell's personal chastisement of McCarthy. Riddell was backed in the McCarthy incident by Dr. Edward Hall Barton, Dr. James Jones and the weighmaster Bertrand.

Dr. Edward Hall Barton's defense of Riddell is important because Barton was a former dean of the Medical College of Louisiana, and a distinguished scientist in his own right. He wrote to Dr. R. M. Patterson, July 17, 1840:

"I take the liberty of addressing you in relation to the 3rd charge made against Dr. Riddell of the Mint of this place. I should have done so before had I thought the charge itself worthy of notice. Having known Dr. R. for many years — having served with him in the faculty of the medical college for four or five years — having seen him in every relation in which one gentleman can see another, my opinion can be put in the same class with the estimate of my character.

"I can then say in brief, that standing as he did in relation to the fellow McCarthy, and taking into account the mode in which public is formed here — Dr. Riddell could not in safety have acted otherwise as he did. You, sir, are fully aware of the value of character; I need not say then how you should and would feel were you assailed as a robber — a defaulter, with every approbrious epithet, by a fellow of fictitious reputation, who not content with verbal slander, sought to blight your name through the public press.

"Dr. Riddell consulted me in regard to the appropriate course of conduct for him to pursue. Though one of the last to advise a resort to violence of any kind, I stated to him that it was his duty to his reputation and the

safety of his sureties first — to prove to the public that the charges were false and malicious libels, which he promptly did by having the whole of his bullion weighed and accurately examined; and then, that as there was but one way of reaching the wretch, and that was through his corporeal feelings, it was due to him so to punish him. A suit for libel or scandal would have been a mere mockery and would have given the fellow an importance he would not reach any other way.

"It was my conviction and is so still, that Dr. Riddell in this community could have acted in no other way — and I do verily believe that he is completely justified in the opinion of all honorable men here.

"I was astonished to see the scandal made of it by his opponents, but it must have been excessively misrepresented, to have reached the dignity of a notice by the Government! Any wretch, however contemptible can "prosecute," but it belongs to our courts of Justice to convict or justify.

"Excuse the trouble I am giving you in calling your attention to this disgraceful charge, and believe me sir, that it is as unworthy of Riddell as of you or myself.

"With respect to Dr. Riddell's scientific qualification he has not his superior in this community; and if he cannot always make himself as agreeable as others, it is because he has sacrificed the specious to the solid; — and though he may want some of the gilding of social intercourse, he has the solid ore of substantial good feelings — of extensive acquirements and unquestionable integrity."

Dr. Edward Hall Barton to R. M. Patterson,
National Archives, Fiscal Section
July 17, 1840

The entire matter was reviewed by Levi Woodbury and by President Van Buren. No reply was sent to Riddell, so he concluded

> "I may regard myself as safely over one more sea of difficulties."
>
> *Persónal Journal,* vol. 19

Actually there was a certain amount of politics involved, since Cammack the treasurer was a Whig, and since

> "... the Democratic papers have begun to make comments on the Whig officers of the Mint..."
>
> *Personal Journal,* vol. 19

Riddell wrote Van Buren and expressed his hope that the situation would not affect Van Buren's political future.

While Riddell may have been ignorant of accepted practices in preparing gold ingots, he did improve the accepted method for silver. He reported to Dr. Patterson that he used a specially designed cast iron pot holding 15,000 ounces instead of the 1,600 ounce size previously used. This proved quite satisfactory, and was used at the Branch Mint as late as 1902. His gold process, outlined in his defense, July 14, 1840, was, according to Patterson, not in compliance with Mint specifications.

During the late summer of 1840 Riddell journeyed northward, essentially on Mint business, but combined this with many visits. He traveled on the Pontchartrain Railroad to Lake Pontchartrain, by packet to Pascagoula, Mississippi, by stage to Mobile, Alabama, Montgomery, Alabama, Columbus, Georgia, Augusta, Georgia, Greensboro, North Carolina, Charleston, South Carolina, by boat to Wilmington, North Carolina, by stage to Petersburg, Virginia, Richmond, Virginia, and finally Washington, D.C., Baltimore, Maryland, and Philadelphia, Pennsylvania. He kept a detailed expense account on this trip, even noting $0.13 for sightseeing at the Washington Monument, and the purchase of a silk hat in Washington.

His visit to Philadelphia was essentially to confer with Dr. Patterson and others at the Philadelphia Mint to clear up some of the difficulties in the processing of silver and gold. He was much pleased with his reception at the Mint. Dr. Patterson took him to meetings of the American Philosophical Society, and he attended the sessions of the Academy of Natural Science. One of the new acquaintances made at the Philosophical Society was Caleb G. Forshey, a geologist from Natchez, Mississippi. Riddell and Forshey were to work together later on a geological survey of Louisiana. Riddell was entertained at a party on September 11, 1840, by Dr. S. G. Morton. All of the prominent scientists of Philadelphia were there, including the botanist Thomas Nuttall whose work Riddell had used while in Cincinnati. The party was quite elaborate, with, as Riddell noted,

> "hock and madeira wines, ice cream, grapes, apples, pears, peaches, sugar cakes, etc."
>
> *Personal Journal,* vol. 19

On his return journey Riddell visited Secretary of the Treasury Levi Woodbury in Washington, and made a special trip to visit President Martin Van Buren out in the country near Washington. In spite of his difficulties at the Mint he asked Woodbury to defray his expenses, since he was on Mint business. Apparently the Secretary agreed to do so, for reference is made to it later.

On the return Riddell traveled from Washington to Wheeling, West Virginia, then to Columbus, Ohio and Cincinnati, Ohio. He met John Tyler, later president, on one of the steamers and, another traveling companion was General William H. Harrison. He learned en route that Catherine Burr had married a clergyman, Reverend Ufford, of Gambier, Ohio.

His visit to Cincinnati was rather unpleasant. Just why he stopped there is not clear, for he had not forgotten how his medical colleagues had treated Mary on the occasion of their marriage. He had not forgiven them for their

> "slanderous misdeeds of the past."
> *Personal Journal,* vol. 19

He met Dr. William Wood, Dr. S. D. Gross and the botanist William Starling Sullivant, but Dr. Daniel Drake was out of the city.

At Cincinnati he decided against a trip to Louisville, Kentucky, and took a stage for St. Louis, Missouri, where he boarded a Mississippi River packet. After many delays he reached New Orleans on October 12, 1840. He recorded that the trip had cost him $518.32.

A year later, Riddell proposed to Superintendent Kennedy that slave labor be used in the melting department of the Mint. He reasoned that most of the duties now carried on by his three laborers could be performed by slaves — carrying coal, tending furnaces, removing ashes, lifting pots from furnaces, sweeping, etc. — and added, that in the hot summer months, the "Creole blacks" would stand the heat better than white laborers, would need no summer vacation, and also would save $720.00 a year. Riddell also felt that the employment of slave labor would reduce the danger of robbery since the slaves could be guarded and restricted. This was a unique position for a New England Yankee to take; especially one who a few years before was not certain he would remain in the South. Kennedy's action on the request is not known.

Another political difficulty confronted Riddell in April, 1841. In a letter to Thomas Ewing, then Secretary of the Treasury, Riddell states that

> ". . . I would not obtrude myself upon you had I not observed this morning in one of our less respectable city papers, an article wherein I was mentioned among others as being obnoxious to Mr. Webster's late circular — falsely charging me with having been an active partisan during the late Presidential election, and having influenced the votes of the men engaged in my department."
> J. L. Riddell to Thomas Ewing, April 8, 1841, National Archives, Fiscal Section

Riddell continued with a refutation of the charges, indicating that the only political gathering he had ever attended was a ward meeting, and then did not participate in the discussions. He was anxious, however, to learn whether or not he would be replaced as melter and refiner. A letter to Ewing from Silas Reed, dated April 29, 1841, requests that Riddell be continued in office:

> "If you have no conclusive evidence that Doct. J. L. Riddell . . . has been a political partizan and in any way prostituted the official trust reposed in him, I hope he will be continued in office. He is a gentleman of high literary and scientific attainments — of good moral character, and a business, industrious man. In point of qualification, industry and integrity, I apprehend no one is his superior. I knew him several years in Cincinnati — and his name is honorably connected with the botany, geology and mineralogy of the West."
> Silas Reed to Thomas Ewing, April 29, 1841, National Archives, Fiscal Section

These letters apparently cleared up this difficulty.

On November 6, 1841, Riddell wrote to President John Tyler, asking to be informed if any charges were prepared against him. He noted in his letter that

> "I have reason to believe that attempt has been or will be made to prejudice my standing with you; for no other real reason than that I have disobliged some of my late friends by refusing to loan money; but for the falsely alleged reason that I have not made a satis-

factory settlement of my silver account."
J. L. Riddell to John Tyler, Nov. 6, 1841,
National Archives, Fiscal Section

He continued to outline the controversy, that Kennedy did not agree with one item in the assayer's certificate which Riddell insisted was correct. The dispute had been referred to Dr. R. M. Patterson for settlement.

His term as melter and refiner at the United States Branch Mint came to an abrupt close December 4, 1848, when Robert J. Walker, Secretary of the Treasury, wrote Riddell a curt note of dismissal, and notified Superintendent Kennedy of his action at the same time. Riddell was not too unhappy about his dismissal, but became annoyed when he was unable to find out the reasons for it. Secretary Walker refused to reply to his letters. On March 31, 1849, Riddell wrote to Walker's successor, William M. Meredith, as follows:

> "I held the office of Melter and Refiner in the Branch Mint at New Orleans, from 1839, until the close of 1848. In the month of December 1848 I received from your predecessor, Mr. Walker an unexpected and unexplained notice of removal from office. After settling my accounts, I addressed Mr. Walker a note, asking for a transcript of charges, or statement of the causes, producing my removal. Receiving no reply, on the 17th of Feb. 1849 I again addressed Mr. Walker, a letter, apprising him that unfounded slanderous rumours affecting my reputation had arisen in the premises, and conjuring him as a matter of justice to communicate to me any and all charges that may have been preferred, in order that I might set myself right. I have still received no reply.
>
> "I therefore address you, as his successor in office, this note, asking that I may be furnished with copies of any letters on file in the department, from which the propriety or necessity of my removal was based. If on political grounds, I am satisfied. But if on assinuations that affect my reputation, then I shall desire that the matter be duly inquired into."
>
> J. L. Riddell to W. M. Meredith,
> March 31, 1849, National Archives,
> Fiscal Section

There is no record that a reply was received in this instance either.

The faculty of the Medical Department of the University of Louisiana, the successor to the Medical College of Louisiana, was also concerned about Riddell's dismissal. On March 29, 1849, Dr. Gustavus A. Nott wrote to Secretary Meredith as follows:

> "Dr. Riddell late melter and refiner in the U. S. Branch Mint at New Orleans has recently been removed from office without any reasons publicly assigned therefor.
>
> "Dr. Riddell is a member of the medical faculty of the University of Louisiana. Reports are rife in the community that he has been removed from the aforesaid office for malfeasance or malpractices in the discharge of its duties. These reports have been brought before the medical faculty in a manner to enforce their consideration, and they have appointed a committee to investigate the charges. I am chairman of that committee. Its object is to ascertain facts. If the character of Dr. Riddell is suffering unjustly we feel it our duty as his brother professors to come forward in his defence. On the contrary if these allegations are true, we feel it no less a duty, to protect ourselves from an association with one rightfully accused.
>
> "Dr. Riddell states to us that he has written twice to the Department, without receiving any reply. Will you have the kindness to furnish us with any information you may feel at liberty to communicate, which has come within your knowledge officially, relative to the removal of Dr. Riddell from office."
>
> Dr. G. A. Nott to William Meredith,
> March 29, 1849, National Archives,
> Fiscal Section

No action was taken by the Medical Faculty, or by the Board of Administrators, of the University of Louisiana, against Riddell, so we conclude that Meredith ignored Nott's letter as well as the others.

XII. NEW ORLEANS – 1840-1846

Even though he enjoyed a professorship at the University of Louisiana, and a responsible position at the Branch Mint of the United States, Riddell was not completely happy in New Orleans. He was in the best financial condition of his entire life, not only with his own income and investments, but with the property inherited from his wife. He noted in his *Journal* on February 20, 1840, that

> "I bought for cash on Monday, before Marks, (Joseph B. Marks) notary public, a negro boy George."
>
> *Personal Journal,* vol. 18

He was also able to send his brother George $100.00 for his education, pay the installment on the mortgage on his mother's farm in Preston, and send money for brother William's schooling, as well as gifts to his sisters and brother-in-law.

His feelings of unrest and dissatisfaction are expressed in his July 19, 1840, entry, just at the close of the early Mint troubles:

> "Ten years have blunted my acute pleasurable feelings very much, but have not lessened my ambition. The objects of my ambition have become more defined and restricted. Poetry I have long since wholly given up. The study of nature is what I excel in. Let me but carry out one half of the plans I have formed — let me accomplish one half of the researches I have proposed to myself, and I shall then feel more satisfied."
>
> *Personal Journal,* vol. 18

Frequently he complained about excessive work at the Mint, and not enough time for personal reflections and reading.

> "I am so annoyed by the responsibility of my situation as Melter and Refiner that I find little leisure for reading or writing, and am unable to make much progress in any of my projects."
>
> *Personal Journal,* vol. 19

In spite of these complaints Riddell was preparing herbaria and drying plants, he was doing independent chemical analysis (such as testing a negro's stomach for arsenic for Glendy Burke, a prominent citizen), and testing the black vomit of yellow fever patients.

The Geological Committee of the State of Louisiana became a reality in 1841, with John Leonard Riddell as chairman, and Dr. W. M. Carpenter, Dr. Thomas Ingalls, Dr. Josiah Hale, Caleb G. Forshey and P. E. Trastour as committeemen. The members of the Committee were supposed to serve without pay, but after submission of their report Trastour sent the Legislature a bill for his services. Not to be left out, Forshey and Carpenter also presented bills. The Governor was greatly annoyed, and appealed to Riddell for assistance. After much discussion the Legislature did appropriate $2500.00 for each of the Committee members. All of the documents which had been turned over to the State Printer were lost before publication. The specimens collected were assembled in the Medical Department of the University of Louisiana, where they were confiscated by the President of the University, Dr. Francis Lister Hawks, and later sent to New York by one of the faculty members, Dr. Charles A. Luzenberg.

An interesting note on a family matter is given in detail in Riddell's *Journal.* At the time of Mary Riddell's death she was buried in the Protestant Cemetery (Girod Street) annex. Two years later Riddell noted that it was necessary to transfer the remains of Mary, the Schragers and their first child John, into a new location within the main cemetery. He drew sketches indicating the location of the tomb, and a drawing indicating how the remains were placed within the tomb.

Additional evidence of his financial success is indicated by his purchase of farm lands in Texas and in New York, and the purchase of a second slave.

> "I bought a mulatto man, cook, etc. for $670 cash. His name is Steward."
>
> *Personal Journal,* vol. 19

He leased his New York lands to his sister Julia Ann and her husband, John Brown.

As was noted earlier, on the journey during the summer of 1840 Riddell met John Tyler and his son. There are frequent references to exchanges of letters between Riddell and young Tyler. His friendship with Harrison and with Tyler made him fairly secure in his position at the Mint in spite of the charges made against him.

Riddell's *Personal Journal* was neglected during the forties, and there are no volumes of the *Repository* after 1835. His scientific speculations were mixed with personal reflections and notes. Entries were sparse.

In the course of his extensive correspondence with Dr. R. M. Patterson at the United States Mint, Philadelphia, Pennsylvania, Riddell suggested that Patterson ask the American Philosophical Society to publish his material on Texas plants, with colored copperplate engravings. Patterson did not look favorably on the idea.

A letter from Riddell to Dr. John Torrey, distinguished botanist, reveals Riddell's desire for continued recognition in this field:

"Your favor apprising me that you had sent a Package of Books per ship Alabama came duly to hand. Neither the Captain of the ship nor the agents here can give any account of the package. May it not have been sent by some other ship?

"I procured many new species of plants among the San Saba Mountains and in Western Texas — Was absent three months, returned 9th Dec. I took copious notes where the plants grew. Going horseback could not often take duplicates. I shall send you such as I have.

"Query: Where I furnish you a satisfactory description of a new plant, in accordance with the plan of your flora, will you let it appear in your flora, in my name — after the manner of Nuttall's Rocky Mountain plants? . . ."

J. L. Riddell to Dr. John Torrey, February 9, 1840, Academy of Natural Science, Philadelphia, Pennsylvania

On March 20, 1842 Riddell wrote to Dr. George Engelmann:

"Your favor of February 8th came to hand a week or two since. I shall be very happy to correspond with you hereafter, sending you the productions peculiar to this region for those of Missouri.

"I have on hand several samples of *Cascata* obtained by me in Texas, which with excerpts from all I have I will send you in time for your monograph — so soon in fact as I get time to look over my unarranged specimens."

Engelmann letters, Missouri Botanical Garden, St. Louis, Missouri
March 20, 1842

During 1843 Riddell was crystallizing his views on the constitution of matter and contemplating meteorological problems, such as the origin of storms, tornadoes and water spouts. He designed a modified reflecting telescope and some semi-cylindrical lenses. His periodic speculations about aerial navigation continued.

In 1844 we find Riddell preparing a book on coins, and formulating tests for the specific gravity of coins, real and counterfeit. *The Monograph of the Silver Dollar* was printed in Cincinnati by E. Shepard, under Riddell's personal direction. The book contains over five hundred facsimile impressions of American and Mexican dollars and half-dollars, genuine and counterfeit, with assays. The book is a collector's item for numismatists today.

Riddell was appointed to the State Flood Prevention Committee by the Governor of Louisiana in 1844,

"to devise a means of protection for New Orleans against the inundations of the Mississippi River,"

Dictionary American Biography, 1935, vol. 15, pp. 589-590

and a year later was a member of a committee of three appointed by the Association of American Geologists and Naturalists

"to ascertain the amount of sediment carried into the sea by the Mississippi River."

DeBow's *Commercial Review* 1846, vol. 2, p. 434

Riddell's paper, "Deposits of the Mississippi and Changes at its Mouth" was read before the Association in 1845, and later published in DeBow's *Commercial Review*. He estimated that 119,250 years were required to create the Mississippi delta. He made many calculations of sedimentation and on several occasions measured the depth of the river at various locations. One of his original plans showing the varying depth of the river in front of his residence (May 12, 1849) has been preserved in the archives of the Howard-Tilton Memorial Library, Tulane University. These studies, some of them with Caleb G. Forshey, culminated in two papers: "Sedimentary deposits of the Mississippi", in DeBow's *Commercial Review* (mentioned above) and "Remarks on the dynamics of the Mississippi River and other matters pertaining thereto," a pamphlet printed in New Orleans. During this period Riddell was also an active member of the Physico-Medical Society of New Orleans.

Another long summer trip was taken in 1844. He left New Orleans by steamship for New York, stopping at Key West, Florida, and Charleston, South Carolina. He spent several days with his mother in Preston, giving her $500.00 for her home and $150.00 for other purposes. Riddell then visited his birthplace, Leyden, Massachusetts, his old home in Colerain, Massachusetts, then Boston and New York. While in Leyden he visited his relatives and determined the genealogy of his family.

There is a bit of mystery concerning Riddell's second marriage, if there was one.

No mention of it is made in his *Personal Journal* nor is there any record of it in the archives of the City of New Orleans. The Riddell *Family Genealogy,* prepared by William Pitt Riddell, John Leonard's brother, and edited by John Leonard Riddell, was printed in 1852, and lists the second marriage to Ann Hennefin, with children Edward Henry, born November 18, 1841, and John William, born December 2, 1844. The births of the two children are recorded in the *Personal Journal,* but not the marriage, leaving speculation about the possibility that Ann Hennefin was Riddell's mistress. This is quite likely the case, since prior to his marriage to Angelica Eugenia Brown in 1846, he refers in his *Journal* to Mary, and how happy they were together, and indicates that he had been a widower for six and a half years.

To substantiate the speculation about Ann Hennefin it will be noted that at the time of the settlement of Riddell's estate the two children mentioned, Edward Henry and John William, were not listed as heirs (1867). When the *Genealogy* was prepared, in 1852, John William was listed in Preston, New York, with his grandmother. Edward Henry was in New Orleans, and was educated by John Leonard at Jefferson College. He later married and two of his children were buried in the Riddell tomb, Edward and Holma Peter Riddell.

One of Riddell's characteristics was his stubbornness. When he established, to his own satisfaction, that a scientific interpretation was sound, or that one of his own experiments was correct, he would stand behind that decision even if proved wrong to the satisfaction of others. Two major disputes over scientific matters took place in the forties. One was an exchange in the local newspapers during October, 1843, with R. O. Davidson over Davidson's plan for a

> "flying machine which he calls an aerostat."
> *Personal Journal,* not numbered

By means of a notice in the *Morning Herald,* Riddell was "invited" to comment on Davidson's project. He was not interested in the publication of his findings, but Davidson insisted. Riddell's calculations, based on the principles of falling bodies, showed that the project would fail. He wrote:

> "In examining your scheme I have become perfectly convinced that it is impracticable for a man to fly by his own muscular power, unaided by a buoyant gas, no matter what mechanical contrivance he may invent to serve him."
> *Personal Journal,* not numbered

Davidson did not appreciate the reply, and countered with:

> "But unfortunately for your deductions and conclusions they arise out of an examination of the mere physical and not the intellectual characteristic of my project."
> *Personal Journal,* not numbered

Davidson's designs attempted to imitate the flight of birds, and not falling bodies. He then claimed the "impropriety" of Riddell's mode of investigation, and thought it had reflected unfavorably on his project. The controversy was followed in the newspapers for two months, with Riddell philosophizing on the relationship between the flight of birds and their physiology.

XIII. SCIENTIFIC ACHIEVEMENTS — 1839-1850

Phosphorescent Taper

Riddell recorded:

> "Melted beeswax in spoon, dropped in piece of phosphorus until diffused. Poured into hollow paper cylinders, ½ inch in diameter, 2 in. long. When cool the cylinder continued to look luminous in the dark, so long as there remained any of the phosphorus exposed to the air. But at anytime by rubbing the end of it upon a board, it would become luminous. Can be carried in pocket without danger of fire."
> *Personal Journal,* vol. 7

Pocket Compass

Riddell wrote:

> "I have hit upon an easy mode of constructing a pocket compass.
>
> OC represents a quill barrel. At O the end is closed with sealing wax; at C, a cork, closing the other end. S is a small lead shot; NS represents a magnetized sewing needle (No. 8). The point is toward S. A spear head is fastened on N for the north pole.

"C has a horizontal perforation for inserting the needle. To make use of it first remove the cork; next, take out the needle, then replace the cork and run the needle through the perforation.

"Lastly place it in still water and the quill, still standing erect, will sink down so that the surface of the water will be at W. The needle will now readily traverse and almost at once settle down to N and S polarity. I varnish quill, needle and all with black Japan varnish. It seems to me that this single contrivance may prove highly useful to hunters, Indians and travellers. It is certainly more portable than anything of the kind ever before contrived."

Personal Journal, vol. 18
(April 5, 1839)

These letters refer to an accompanying diagram in the *Journal.*

Typewriter

The typewriter as we know it was not developed until 1868, but the idea of such a machine was proposed by Riddell in his *Journal,* May 29, 1831.

> "I planned a writing machine — intended to have it go by keys — so constructed that letters might be impressed as rapidly as keys could be touched with the fingers of both hands. I supposed that fair letters resembling printing might be made nearly fast enough to keep up with a speaker."
>
> *Personal Journal,* vol. 18

This machine did not go beyond the planning stage, but there are references indicating that Riddell wished he had completed the machine. On August 25, 1842, he wrote:

> "I have again been thinking of an expeditious mode of extemporaneous printing by means of keys and mechanisms . . . thirty keys to a row . . . fifty such rows . . . enough to furnish a line on a book or manuscript by taking a letter or blank from each."
>
> *Personal Journal,* vol. 19

There were preliminary construction sketches, but nothing was ever made. To my knowledge Riddell has never been associated in any way with the invention of the typewriter, yet the idea seems to have been his many years before the actual invention. Riddell's ideas do not antedate the British patent of 1714 which some regard as evidence of the first machine, but his thoughts precede the designs of Charles Thurber and Sir Charles Wheatstone.

Fishrod Balance

This instrument was constructed in 1840 and reported in the *American Journal of Science and Arts* in 1858.

> "I formed a minute tapering hollow tube of glass, mounted it adjustable in a glazed case to avoid drafts of wind, suspended from the small and free end an extremely light pan by a thread of glass, terminating in an indicator point, the point traversing over a micrometer scale, a view of which was commanded by a microscope."
>
> *American Journal of Science and Arts,* 1858, vol. 26, p. 71

Riddell stated that he had operated this balance for some years and that its operation was witnessed by "hundreds of people now living." The instrument was "delicate and reliable" and was used to determine the amount of non-volatile matter in liquids, which gave films too minute for an assay balance. Riddell admitted that the balance was not too accurate, because repetition did not give comparable results throughout the year.

Views on the Constitution of Matter (Atomic Theory)

The first indication of interest in the atomic concept of matter was given in a lecture at Worthington, Ohio, on June 24, 1833. From that time until 1850 Riddell's notebooks are filled with his interpretations of the constitution of matter. These notes reveal that Riddell believed that matter was composed of atoms, and that each atom was in turn composed of an infinity of particles, and that these particles were composed of an infinite number of smaller particles, *ad infinitum.* He regarded the sun and earth as atoms, and attempted to link up the solar system with the atomic system.

Riddell's paper "The probable constitution of matter and the laws of motion as deductible from and explanatory of the physical phenomena of nature" is based on the following propositions:

1. "Matter is any thing real, which occupies by itself length, breadth, and thickness in space.
2. "Matter exists aggregated into spheroids or atoms forming in respect to the dimen-

sions of the different terms of atoms an indefinite series, probably geometrical, in which each atom is composed of an aggregation of an indefinitely great number of atoms subordinate in the series with respect to size . . . Let

M = a visible, material sphere, like the sun or earth

$\bigcirc$ = any ratio, infinitely small

$\backsim$ = any ratio, or quantity, infinitely great

∞ = any ratio, or quantity, indefinitely great

then the material series may be written in geometrical proportion thus:

$$M \backsim : M : M\bigcirc : M\bigcirc^{2} : M\bigcirc^{3} : \ldots : M\bigcirc^{\infty-2} : M\bigcirc^{\infty-1} : M^{\infty}$$

"Here

$M\bigcirc$ = a molecular atom, such as oxygen or any other of the so called chemical elements;

$M\bigcirc^{2}$ = a more attenuated matter, probably such as an atom of the luminiferous medium;

$M\bigcirc^{3}$ = matter probably instrumental in producing the phenomena of attraction;

$M\bigcirc^{\infty}$ = the unassignable, transcental last term of matter.

"... to assign a last term of matter on the scale of minuteness would be to set limits to a subject which wears every aspect of infinity. Whatever we call great or small, cannot be absolutely great or small; only relatively so. And if there be an assignable ultimate atom of matter, no reason can be given why it should have any special limit of dimensions. Admit its existence and then comes the natural inquiry as to its theoretical divisibility; which affirmatively forcing itself upon our conviction, we are again compelled to assent that there cannot be assigned an ultimate term of matter.

3. "Around each material atom or aggregated sphere, there lies a sort of atmosphere or medium, consisting of diffused atoms belonging to the subordinate terms in the material series.

4. "Matter is inherently inert, or posses what has been called vis inertiae; by which is meant that matter can neither of itself begin to move, nor cease to move when set in motion.

5. "Matter is indestructible.

6. "Matter is inherently and necessarily possessed of no qualities, unless its extension, mobility and inertness be called qualities.

7. "Motion, existing in time, (of which it is the cause and measure) is the translation of matter through space.

8. "Motion is the source of all qualities, and the proximate cause of all phenomena which matter exhibits.

9. "Momentum is physically indestructible and uncreatable.

10. "Momentum is transferable from matter to matter solely by impact or collision."

New Orleans Medical and Surgical Journal, 1846, vol. 2, pp. 592-623

In this paper he discusses impulse, the indestructibility of motion, the motion of the fixed stars, attraction, gravitation, molecular repulsion, capillary attraction, elastic collisions, gaseous diffusion, the nature of heat, density of gases, and includes a calculation of the time required for a single molecular oscillation in air!

The paper is tedious and on occasion faulty in its reasoning and general logic, but Riddell's picture of the atom, that it is composed of smaller particles, and that these particles are held together by "lines of force" is indeed unique because it is our present-day picture predicted many years before the discovery of our atomic particles.

His concept of momentum is indeed correct, representing that quantity by the product of mass and velocity, but the concept of force is erroneous. His statement

"The terms force and power, though often vaguely used, mean generally momentum,"

New Orleans Medical and Surgical Journal, 1846, vol. 2, pp. 592-623

is completely wrong.

A few additional paragraphs to elaborate on his picture of the atom may prove of interest:

"Each atom is supposed to be surrounded by an atmosphere of calorific and electrical matter. This subtile envelope of ethereal matter as it has been termed, is self-repellant, though attracted by the atoms which it surrounds. Its presence, however, renders the atoms mutually repulsive, a quality which does not fail to manifest itself, wherever from proximity or other cause it has the ascendancy over the inherent corpuscular attraction."

> "Atoms enveloped in similar electric fluids will have a disposition to repel each other; if dissimilarly electrified there will be a tendency to mutual attraction."
>
> *Repository,* vol. 6

Riddell's publication received the following press notice from the editors of the New Orleans *Commercial Bulletin:*

> "On the Constitution of Matter, by Prof. Riddell, is written with care and perspicuity, and will doubtless attract much attention. With some additions, it is a systematic arrangement of the peculiar philosophical principles of the writer, heretofore announced in the columns of the *Commercial Bulletin.* Though much controverted, his philosophy is deserving of a careful examination and will attract attention from the ingenuity and ability with which it is maintained."
>
> New Orleans *Commercial Bulletin,* 1846

The Ely-Riddell Controversy

In January, 1846, one of the significant controversies of a strictly scientific nature involving John Leonard Riddell arose. The issue was Riddell's presentation of the "Constitution of Matter", in lecture and publication. The newspapers carried lengthy arguments and detailed rebuttals, until the editors finally grew tired of the debate and dropped the issue.

The discussion began with a criticism of the Riddell point of view concerning gravitation and matter, printed in the New Orleans *Commercial Bulletin,* and signed "E". Riddell immediately answered, whereupon "E" attacked the answer. The exchange occupied almost the entire month of January. "E", we know from later publications, was Dr. Albert Welles Ely, a brilliant physician and capable scientist in his own right.

In his publications Riddell had stated his theory of "impulsive" gravitation, as opposed to "inherent" gravitation. Riddell favored the "impulsive" interpretation, for he believed that gravity

> ". . . cannot be material, else it would necessarily be inert like other matter. It would require to be forcibly radiated to other objects or bodies proposed to be affected by it; in which case it would necessarily produce repulsion rather than attraction. . .
>
> "If gravity be not matter, then it cannot be conceived to exist in space, and if it does not exist in space, it exists nowhere, and must be nothing. Gravity cannot be abstract motion or momentum, for motion or momentum obviously can have no existence separate from matter moving. . .
>
> "The force of momentum giving origin to the phenomenon of gravity must therefore have had an equivalent congeneric antecedent existence, essentially in the direction of the body moving in obedience to it."
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 2, pp. 592-623

This, to us today, seems to be so much nonsense. Ely thought so also, and ridiculed Riddell in scorching terms:

> "He disavows the necessity of the motion of matter, he eschews the philosophy of Newton and LaPlace, as to the cause of motion — he declares the doctrine of universal inherent gravitation as an absurdity, what then will he assign as the causes of the impulses of motion in his ponderefacient medium? Is it more satisfactory or simple then to explain natural phenomena by Prof. Riddell's theory than that of Newton? Does the new theory point out and supply any deficit in the old one? Assuredly not."
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 3, p. 3

Concerning the arguments for the existence of gravity in space, Ely comments

> "This, if true, proves too much; for it would prove the nonexistence of mind. Mind is not matter, yet it exists in space, and operates upon things in space."
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 3, p. 3

Ely frankly admits that

> "gravitation is one of the profound mysteries of nature — the instrument by which the Creator propels through space the countless worlds of the Universe. It is as mysterious as mind; and it is no more absurd to suppose its existence as a powerful active principle pervading all matter, than to suppose the existence of mind.
>
> "Professor Riddell rejects inherent gravity because he cannot comprehend it, and tries to in its place material impulses of motion — but unfortunately here too he meets with something which he cannot comprehend — the cause of his impulses of motion. He is therefore compelled to stop. . ."
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 3, p. 3

Commenting on Riddell's publication of the "Constitution of Matter" Ely summarizes the important points of the paper, adding his

own phrases. He believed that the Riddell theory was based upon:

1. ". . . a theory of the constitution of matter of which we know absolutely nothing and never can know,
2. "an extremely subtile ponderefacient medium the very existence of which cannot be proved;
3. "impulses of motion traversing this ponderefacient media in every direction, thus giving rise to the motion of bodies in space, This is a pure hypothesis of which we know nothing and of which nothing can be proved;
4. "the indestructibility of motion which is not proved;
5. "the doctrine of collision as a means by which motion is communicated from matter to matter which I have shown cannot be true;
6. "that motion is the sole quality of matter — which I have shown to be false."

New Orleans Medical and Surgical Journal, 1846, vol. 3, p. 3

Riddell was not disturbed by this challenge, and merely brushed aside Ely's objections with sarcastic phrases. Ely, of course, hit some of the weaknesses of Riddell's point of view, and was for the most part correct in his interpretation.

Ely did not quarrel over the portion of the paper dealing with the actual structure of matter or the concept of atomic and nuclear binding forces. He accepted, as we do today, the validity of those sections.

The Riddellian Philosophy

In 1846, following the publication of his paper on the "Constitution of Matter", Riddell wrote in his *Journal* his "Philosophy" — or, rather, his views on God, matter, the hereafter and the universe. Some of these points were noted in his publication on the "Constitution of Matter," others are completely new:

1. "That the essence of matter exists, but was never created, having always existed.
2. "That all the motion now pertaining to the matter of the universe always existed.
3. "There can be nothing else besides matter and motion.
4. "That since a universal corelation must submit through the agency or impulse, among all the infinite parts and stems of the universe; the movement of each particle etc indelibly recording itself by an influence on all nature; there must exist a universal consciousness, very properly termed the mind of Deity.
5. "That regarding the transcendental terms of matter there can be no conceivable limit to the velocity of impulse therein, and hence the mind of Deity throughout any conceivable region of space, however vast, appreciates all occurrences within any interval of time however infinitessimaly minute it may be assigned.
6. "That all the laws of nature depend upon the mathematically necessary axioms of impulse.
7. "That the laws of nature are imperative and unrelenting and though I cannot comprehend the subject, yet I cannot but infer that our moral acts are sooner or later productive of effects resulting in exact and absolute justice.
8. "Personal identity is probably not a thing permanent in nature. On this point I do not feel clear and decided. It seems that personal identity and individual existence may be likened unto a lamp or rather the flame of a lamp — a continued succession of like phenomena.
9. "As to future state I cannot for a moment doubt but that the matter and motion I now possess will survive hereafter in perpetuity. Yet I cannot settle in my mind, whether my mind is some aggregation of transcendental matter, which may survive the body or not. I cannot promise myself a future consciousness after death, of this present existence, because I do not now possess any consciousness of having existed heretofore; yet no doubt all of matter and motion which I possess has always existed. It seems to me most reasonable to suppose that, after death, all I am will merge unconsciously into the general universe of matter and motion.
10. "Therefore nothing can here be certainly determined about a future state of existence: by which I mean that if we in a future state (which I doubt) still retain mental identity or a remembrance of events of this life, we have no possible means of foreseeing or foreknowing the particulars of such future existence.
11. "That every present finite form, body or aggregation of matter (globes, chemical elements, etc) had a beginning or origin, and as such will therefore have an end or dissolution.

12. "That stellar atoms have originated by the condensation of nebulous matter; and that this sort of aggregation seems in progress with all that portion of space which has been explored through the telescope by terrestrial observers.

13. "That in other far unseen regions of space, a process the reverse of nebular condensation may be going on: by which stellar atoms are in progress of expansion and dissolution.

14. "That chemical elements are formed by the aggregation under definite circumstances of matter ($m\theta^2$); the variation of circumstances determining the mass and inherent rotary motion of these chemical elements: hence the origin of different kinds of elements.

15. "That this elemental formation must precede and also concur with this nebular condensation into stellar atoms.

16. "That since we found that a cubic foot of space in the air near the sea, contains 1.1 oz. av. of air, we cannot therefore infer that 1.1 oz. represents the whole mass of matter in that space. In fact by this weight we recognize only the $m\theta$ atoms (molecular atoms) while the same space contains also the $m\theta^2$, $m\theta^3$, $m\theta^4 \ldots m\theta^{\infty-2}$, $m\theta^{\infty-1}$, $m\theta^{\infty}$ atoms: an infinite number of terms of matter besides the $m\theta$ atoms above. Hence the actual amount of water in the said cubic foot of space may be far more than what 1.1 oz. would represent. Hence what to us seems a vacuum may contain much matter.

17. "That the necessary laws of nature are such, as to allow of the origin of organized beings; the aggregation of many different terms of matter into such organisms, being under the control of circumstances.

18. "An organized being has absolute individual and material identity but for an inappreciable moment; it has ordinary individual identity during its life as an individual; it has another and less definite identity as a variety; another as a species; another as a genus; and still another as representing all the forms into which it may be developed in the course of time; the latter being perhaps equal in duration to continuance of the globe in a habitable condition.

"That the more attenuated terms of matter have a preponderating influence upon the more gross terms of matter, as $m\theta^2$ upon $m\theta$, $m\theta^3$ upon $m\theta$, etc. So mind, the immediate instruments of which are the transcendental terms of matter, has an influence upon matter. This arises from the greater velocity of impulse in the refined terms of matter compared with the velocity of normal impulse in the grosser medium."

Personal Journal, not numbered (1846)

A curious paragraph from Riddell's *Journal,* following the Ely controversy and the statement of Riddell's philosophy, deserves mention.

"I do not think there is in, or out of nature, a separate and independent being called Deity; but that Deity is the infinite total of all; the grand organization which includes all others. That I for instance as well as the meanest or most exalted thing known, am an infinitessimal part of Deity."

Personal Journal, not numbered

In May, 1846, Riddell announced his concept of molecular matter. He postulated four states — nebular matter, solids, liquids and gases, and characterized them as follows:

1. "Nebular condition, in which the atoms are so remote as not to manifest sensibly molecular attraction or repulsion upon each other, and hence they cannot be considered as constituting a medium able to transmit molecular impulses. . .

2. "Gaseous condition. Molecular attraction feeble, almost insensible, from the remoteness of atoms, yet from the adjacency of the proper atmospheres of each atom, symmetrical position is taken, each atom being ivested by others dodecahedrally and molecular impulses, constituting sound (and essentially heat also) are transmissible. Hence molecular repulsion operative.

3. "Liquid condition. Molecular attraction and repulsion both operative, and mutually counterbalancing; atoms ivesting other dodecahedrally.

4. "Solid condition. Molecular attraction and repulsion operative, polaric attraction and repulsion operative, general tendency of atoms to ivest each other bilaterally or in obedience to the axes of polaric rotation."

Personal Journal, not numbered

Two other illustrations of the Riddellian Philosophy appear in later publications. These reveal a different side.

". . . as to the relations of animals and plants among each other it can safely be said that they prey upon each other to the full extent

of their power . . . that as we in the brief day of our actual observation have seen organic individuals begin and end their respective lives; organic varieties as of fruits, etc. appear, flourish, and decay; and even organic species . . . become extinct, as the Dodo and the Irish Elk; so we may infer, from the inspection of the remains of successive extinct races of beings, that all species or kinds, as such, have begun their career, will flourish for we know not how long, and will ultimately decay and disappear; their places to be supplied by modified species and kinds. . ."

". . . and as to simplicity of structure, any one accustomed to the use of a good microscope, can easily assure himself that the simplest structure visible, really possesses a degree of organization which far transcends the defining power of the instrument; so that truly primitive or elementary structure has never yet by human eyes been seen."

"Organized and living bodies can receive, absorb, elaborate and assimilate dead matter from the mineral kingdom; but no authentic instance is yet adduced, among the myriads of scrutinizing observations made, where mineral matter by itself has elaborated and exalted itself into the organized and living condition . . . we may indeed set it down as established that organized matter had its inception with organized matter anteriorly existing; that all living beings are descended from living beings; just as motion is exclusively derived from pre-existing motion, and just as the present material combinations are derived from pre-existing matter."

New Orleans Medical and Surgical Journal,
1852, vol. 8, pp. 468-480

And in the words of Dr. Noah Benedict, secretary of the New Orleans Academy of Sciences, reporting one of Riddell's pronouncements at the October 10, 1853, meeting of the Academy:

"He had no patience with the arrogant assumption that all things in this world were valuable or worthless, only as they may contribute to the interest or gratification of man. He did not believe we have "a prescriptive or divine right to destroy all of the animals, catch all the fish, nor shoot all the birds." He thought there was some unexpressed law controlling the destinies of our own race, in common with those of all animated nature, which, neutralizing all the forecast of political economy, the calculations of science, the resources of art, like a relentless creditor, exacts to the uttermost the conditions of its bond; which by war, by pestilence, by famine, by some strange, merciless catastrophe, at periods neither ill-defined nor remote, sweeps its myriads to the grave."

New Orleans Academy of Sciences, *Minutes*
October 10, 1853

These extracts give a clear picture of Riddell's concepts on a variety of subjects, points of view which he adhered to strictly and through the years. A close reading of the various paragraphs is required to obtain the full meaning of his rather peculiar beliefs.

Aerial Navigation

From his earliest years with Randolph Williams and their nocturnal ramblings together the ideas of a trip to the moon and an "aeronautic car" fascinated Riddell. In Ogdensburg, New York (1831) he contemplated an essay or lecture on the subject, and jotted down some random notes. Included were the following topics:

"Dedalus and the other Ancients who flew. Artificial wings, broom sticks and necromantic jaunts. Montgolfier's confined clouds. Popular accounts of clouds. Inconvenience that it cools copper cylinders. Pyrenious principle of lightness. A man with a phial of it in his pocket. Inflammable air used for balloons . . . Beauty of the scene above the clouds. Some one ought to set Darwin's inflammable air on fire. Proof mathematical that a balloon might ascend ad libitum. The shape of the balloon is wrong. One ought to be made like a fish. Describe one minutely, with the machine. Carry a gass, telescope, compass, barometer, thermometer, food, drink and notebook. Its rapidity. How to keep warm in it . . . Describe an ascent from a hill overhanging a village. Meteorological discoveries — enter thunder clouds — visit to the airy and misty regions where rain, hail and snow is made and those regions prolifick with fireballs, shooting stars, meteors and the aurora borealis. Cross ocean. Explore the course of the Niger. Survey Ethiopia, Siberia and see the wild dangerous animals of the hot desert while cooly seated at an enormous height above them. Explore the dismal precipices of ice around the Himmalah mountains. Explore the south sea, hunt up the frozen remains of antediluvial animals on the farther shores of America. . ."

Personal Journal, vol. 1

"Send an expedition to the moon. A wonder that in the present age of enterprise no expedition should have been projected to the moon which is so near to us. Explain the attraction of gravitation which makes bodies

> tend downward. Another contrivance necessary to go to the moon is to cut off the attraction of gravity or hinder it from acting through coats of any vessel. . ."
>
> *Personal Journal,* vol. 1

Riddell proposed to give his essay the following title:

> "Essay on various philosophical subjects, by the late learned and eccentric philosopher Baron von Kutzko of Astrachan, containing his aerial adventures, voyage to the moon, etc. Faithfully translated from the Russian."
>
> *Personal Journal,* vol. 5

These fancies were eventually put together in a lecture for the People's Lyceum in New Orleans on April 30, 1847, and published under the new title,

> *"Orrin Lindsay's plan for aerial navigation with a narrative of his explorations in the higher regions of the atmosphere, and his wonderful voyage round the moon."*

Orrin Lindsay's space ship was a balloon made out of metal which was unaffected by gravitation. Inside the balloon were all of the instruments mentioned in his 1831 notes. The occupants discussed their oxygen supply, the temperature of the rarefied atmosphere, and the possibility of collisions with meteorites. The lecture was published at the request of a group of prominent New Orleans citizens, including S. J. Peters, M. M. Cohen, Christian Roselius, H. B. Cenas, J.D.B. DeBow, and others, by John C. Noble of Louisville, Kentucky, and also in New Orleans at Rea's Power Press Office. The lecture and pamphlet were reported in DeBow's *Commercial Review* with the comment

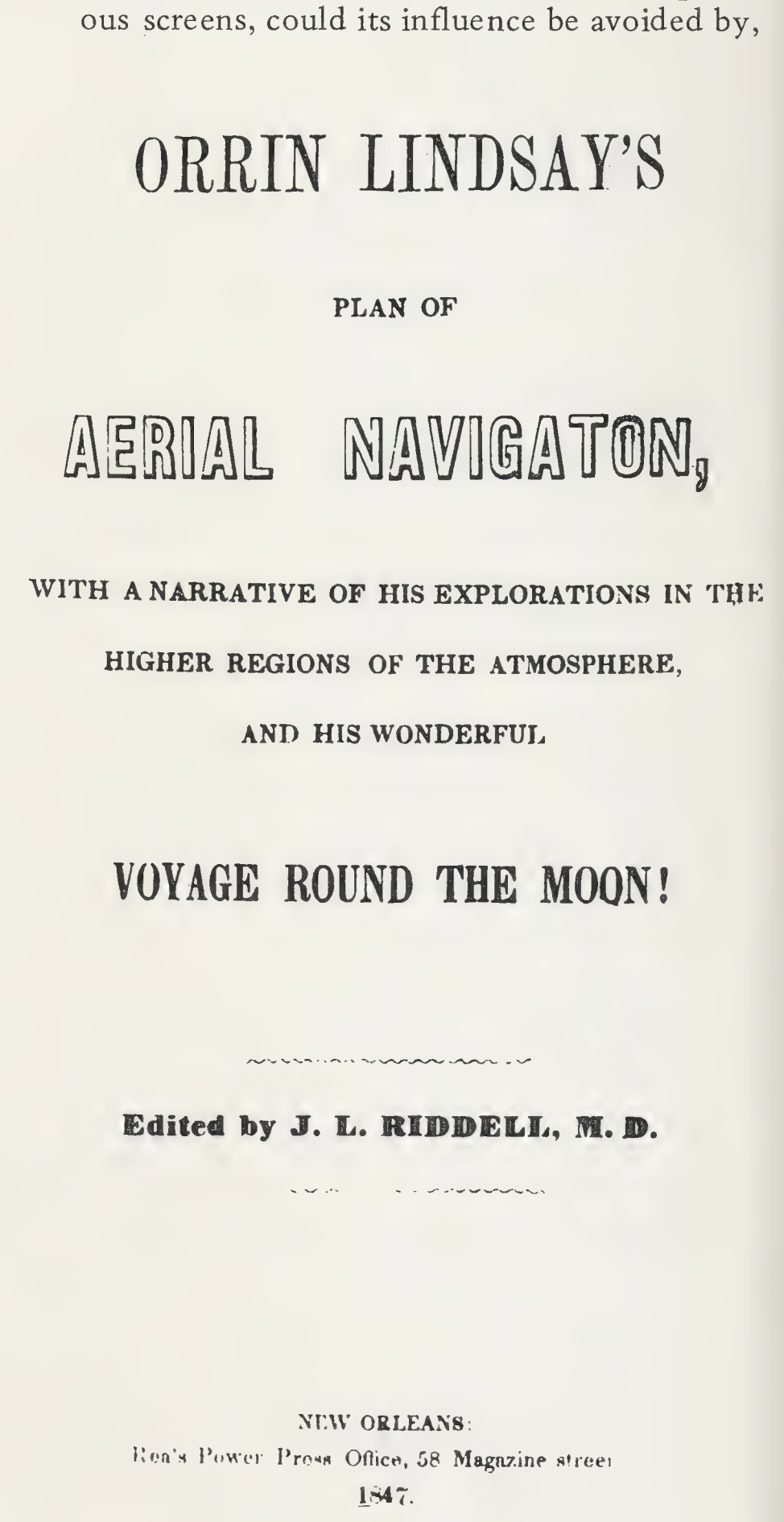
> "Professor Riddell, in a sportive whim . . . made strict science tributary to his fancy."
>
> DeBow's *Commercial Review,* 1847, vol. 3, p. 587

"Orrin Lindsay" is perhaps the cleverest bit of writing Riddell did. He created the character of "Orrin Lindsay" as an Ohio student, but in most of his traits we see the author himself, in his earlier years.

> "Mr. Lindsay, believing with the followers of Newton that gravitation, the grand principle that sustains the planets in the orbits, and gives weight to terrestrial objects, is the result of a direct influence which matter exercises upon matter, near or remote, conceived the possibility of compounding and preparing a substance of such a molecular structure, as to be to this influence impervious. This impervious substance would manifest no weight, for gravity could not act upon it."
>
> *Orrin Lindsay,* 1847, p. 6

Riddell then proceeds to state that in his opinion Mr. Lindsay was in error, that

> ". . . gravitation was not the direct, occult, immaterial principle generally supposed, but the rational effect of material impulses, in some attenuated medium of matter, and that therefore, by no conceivable or possible arrangement of material molecules or impervious screens, could its influence be avoided by,



ORRIN LINDSAY'S

PLAN OF

AERIAL NAVIGATON,

WITH A NARRATIVE OF HIS EXPLORATIONS IN THE

HIGHER REGIONS OF THE ATMOSPHERE,

AND HIS WONDERFUL

VOYAGE ROUND THE MOON!

Edited by J. L. RIDDELL, M. D.

NEW ORLEANS:
Rea's Power Press Office, 58 Magazine street
1847.

Figure 5. Title page of Orrin Lindsay's *Plan of Aerial Navigation* (New York Public Library).

or diverted from terrestrial bodies."

Orrin Lindsay, 1847, pp. 6, 7

He then devotes a page to a quotation from the "Constitution of Matter" on his theory of gravitation.

Lindsay is portrayed as writing Riddell that he has succeeded in preparing a material and has made a voyage into space. Lindsay's account begins

> ". . . I found well prepared steel, after being superficially amalgamated with quicksilver, and then strongly magnetized, to possess the quality of an impervious screen, to the influence of gravitation."
>
> *Orrin Lindsay,* 1847, p. 12

Lindsay experimented with blocks of the coated metal, and with plates made into a box. Such a box ascended into the air, and could carry weight. He even sent aloft in such a box a small dog. He then continues to describe the construction of the balloon used in the first aerial voyage:

> "Its external form was globular, and ten feet in diameter. It consisted of a strong frame of wood work, covered with poplar boards, upon which, externally, were secured plates of the magnetic amalgam. There was one considerable opening, in the manner of a door, into the interior, externally also covered with the amalgam; and twelve circular spy-holes, or windows, symmetrically and equidistantly placed over the whole surface of the sphere, each one six inches in diameter, with twelve plates of the magnetical amalgam to close the openings at pleasure."
>
> ". . . I entered the balloon alone; not without some misgivings. I seated myself, lighted a wax taper, closed the twelve spy-holes; – the rope was loosened. An indescribable sensation seized me. I could not distinguish up from down. I had lost all bodily weight. The flame of the taper became globular and less luminous; – the heated air from it, seemingly not knowing which was to rise, diffused itself slowly in every direction. The slightest springing effort, sent me slowly from one side of the balloon to the opposite . . . and got at an air gage, and observed that the pressure of the air was about half what it is at the surface of the earth, from which I inferred that I had attained an elevation of three miles and a half. I immediately opened several of the windows, until I found in which direction the earth lay. Instantly the force of gravitation took rule again, and the rapid ascent was checked. Bodies acquired weight and the perception of up and down was re-established. . ."
>
> *Orrin Lindsay,* 1847, pp. 15, 16

The narrative continues in that vein, including some scientific calculations and observations, and also the physiological effects of altitude. It is interesting to compare Riddell's treatment of space travel and space ships with that of our modern space explorations. Many of the same basic ideas are treated by Riddell, in a light, whimsical vein, to be sure. Lindsay's description of the surface of the moon and his view of the earth from the moon are particularly well done.

At intervals prior to the publication of "Orrin Lindsay" Riddell speculated on aerial navigation. He was convinced that this was possible, and in May, 1839, proposed a new balloon made of a thin gilded sheet copper

> "with a copper lined room for the aeronaut."
>
> *Personal Journal,* vol. 18

He revised his design in 1841, tending to a

> "long and flat aerial vessel with wings or fins, beak and rudder."
>
> *Personal Journal,* vol. 19

He predicted that such a machine should

> "never have any ascending power, but always a preponderance of weight over levity."
>
> *Personal Journal,* vol. 19

In June, 1842, he described a peculiar gadget:

> "I would depend on wings for locomotion; have always a preponderance of gravitation, which preponderance should lie in a wooden pole say 50 ft long, on the lower end of which could be put at pleasure, a light wheel of 12 ft or so diameter, a delicate model of a vessel to run through water or a smooth metal surface to run on snow or ice."
>
> *Personal Journal,* vol. 19

Riddell's controversy with R. O. Davidson over Davidson's aerostat has been discussed elsewhere, but this was the start of many calculations on aerial problems, always linking them with gravitation and the theory of freely falling bodies.

None of the lesser speculations are developed in the style and humor of "Orrin Lindsay", and there are evidences in it of the use of some of his earlier material. It is certain that after Riddell seriously considered some of the gadgets – the "aerostats", "aerial cars" etc. – that he recognized the impossibility of their design and abandoned most of his proposed space ships.

The following paragraph appeared in the *Western Medical Reformer and Eclectic Journal,* written by Joseph R. Buchanan:

> "Prof. Riddell. We have received from this gentleman a quizzical pamphlet, purporting to describe a voyage to the moon, being a copy of his lecture before the New Orleans Lyceum. It is ingeniously written, and we suppose may be regarded as a scientific burlesque upon the old theory of gravitation which Dr. R. is endeavoring to demolish, The essay of Prof. Riddell, upon the constitution of matter, in which he purposes a new theory of gravitation, is a profound and ingenious production; one which, in our humble opinion, entitles him to a high rank among the savans of the 19th century. We regret that a copy is not at present within reach. Will Prof. R. do us the favor to send one?" B.

Western Medical Reformer and Eclectic Journal, 1847, vol. 1, no. 1, p. 24

Mathematics and Mechanics

Riddell's sole attempt at publication in the field of mathematics was a brief article on logarithms, appearing in the *American Journal of Science and Arts,* 1849. All Riddell did was to write down the general rule for taking roots or raising to powers for ordinary logarithms, using some of his symbolic language. There is nothing original in the paper.

Another speculation was based on his idea that "there is no possible formula in algebra that cannot be expressed in space."

> ". . . in regard to the projection or modelling of the powers in space there are but three species of forms, namely, primarily, the point, the line and the surface; secondarily, the finite cube, the parallelopipedon and the parallelopipedon squared, etc. repeating the analogues of the point, the line and the square. In relation to space there is a remarkable series of seven terms, in geometrical progression, the ratio of which is infinite, which may be expressed

$$0 : 0\infty : 0\infty^2 : 0\infty^3 : 0\infty^4 : 0\infty^5 : 0\infty^6$$

In this symbolism 0 = zero; ∞, infinity; 0., a point; 0∞, a finite line; $0\infty^2$, a finite square surface; $0\infty^3$, a finite cube of space, the analogue of the point; $0\infty^4$, a parallelopipedon of infinite length, the analogue of the line; $0\infty^5$, the same square, the analogue of the surface; $0\infty^6$, an infinite cubic space, the analogue of the point."

New Orleans Academy of Sciences, *Minutes.*

Riddell's ideas of natural philosophy (physics) were obtained solely from reading and from his own experiments. He had no formal training in the subject so far as we are able to determine. Some of the fundamental ideas of mechanics intrigued him, and brought forth some extraordinary hypotheses. During his stay in Pittsburgh he recorded his talks with Dr. Bruce, president of the Western University of Pennsylvania, about

> "the ratio in which air or other fluids would impede a body moving with different degrees of velocity."

Personal Journal, vol. 4

Bruce maintained that

> "the obstruction of air was directly as the square of the velocity,"

Personal Journal, vol. 4

but Riddell remarked

> "now though that is undoubtedly incorrect I will make some calculations thereupon."

Personal Journal, vol. 4

And then he proceeded to calculate for four pages, deriving a complex formula for the velocity of particles moving through a resisting medium in terms of the diameter of the particle.

Later he changed his opinion and accepted the proportionality Bruce stated, for in some of his aerial calculations he lists the following assumptions:

1. "Resistance of medium proportional to v^2 of moving body.
2. "A cylinder moving endwise through a resisting fluid encounters four times the resistance of a sphere of the same diameter and moving with the same velocity;
3. "A spherical drop of rain of 1/10 inch in diameter would have, in falling through air, a terminal velocity of 10.48 ft/sec."

Personal Journal, not numbered

Riddell's master philosophy of the source of motion is peculiarly stated:

> "I conceive radiation from the sun to be the remote source of all terrestrial motion, as winds, currents of matter, and the motion of organic life; and I conceive radiation from the earth to be the grand outlet of the momentum which manifests itself in the earth's surface. . ."

Personal Journal, vol. 18

He always spoke and wrote in terms of momentum rather than force. His concepts

of momentum and collision theory are those we use today. In his words, when a solid moves through a fluid, there is a change of momentum.

> "Here momentum is transferred from a ponderable solid to a ponderable fluid."
>
> *Personal Journal,* vol. 18

Related to this idea is his concept of friction:

> "Friction, then, is the expression of the transference of momentum, from ponderable to imponderable matter. The converse of this transference occurs, i.e. the transference of momentum from imponderable to ponderable matter, as in the steam engine, the electromagnetic engine, the motion of living systems. . ."
>
> *Personal Journal,* vol. 18

> "It is well known that friction is attended with an elevation of temperature and what is sensible caloric but ethereal matter in motion."
>
> *Personal Journal,* vol. 18

Riddell did not agree with Newton's theory of gravitation, and proposed his own theory of the radiant cause of gravitation. He believed that gravitation

> "is caused by the radiations of ethereal particles in all directions, having the power to impart their momentum to ponderable matter. Particles of the subtile matter are flying with immense velocity in all directions through space. A cannon ball or other object in the air has a tendency to approach the earth because it receives the impulses of those moving particles from all directions except toward the earth, where the momentum of those due from that direction has already been intercepted."
>
> *Personal Journal,* vol. 15

He claimed that he was able to reconcile his theory of the radiant cause of gravitation with Newton's inverse square law, since

> "the influence of all radiation in right lines decreases inversely as the square of the distance from the radiant source."
>
> *Personal Journal,* vol. 18

In the words of Dr. Albert Welles Ely, Riddell's substitute for Newtonian gravitation is the impulsive doctrine:

> ". . . that all the vast empyrean of nature is filled with a species of extremely subtile matter, or ether, as Euler calls it, or giving it its new name used by Professor Riddell, ponderefacient matter, by virtue of which all bodies have weight . . . Next it is supposed that this medium in which all the celestial bodies are suspended is traversed by right-lined impulses of motion in every direction and of course acting on everything contained in it."
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 3, p. 3

> "A body then upon which these impulses of motion act in every direction without obstruction will be perfectly at rest; but if another body intercepts the impulses of motion, in any direction, the two bodies will immediately begin to approach one another . . . a body for example approaches the earth or sun because the impulses of motion are interrupted in the direction of the earth or sun by those bodies, and thus the opposite impulses are left to act alone upon the body."
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 3, p. 3

Riddell firmly believed that

> "this subtile ether may thus be the cause of gravitation."
>
> *Personal Journal,* vol. 18

The nature of this ether was set forth as follows:

> "Is not the interstellar medium of luminiferous ether necessarily a resisting medium? I infer it must be so after this wise: it transmits luminous and other effects of a material nature, and therefore it must be material. Being matter its particles are capable of motion, and would in moving possess momentum; we see that mechanical and chemical action set light in motion, in which case the luminiferous either derives momentum from common matter. (The converse therefore must be true, that the momentum of the luminiferous ether can be imparted to common matter). A planet moving through space thus occupied must communicate momentum to the luminiferous ether, and thus in the same degree be robbed of momentum itself. These effects are manifested in the retarded motion of the planets in any assigned time, though of enormous duration may be inappreciably small, and hence may ever to us elude direct observation.Yet I am under the impression that the inference of resistance must be admitted."
>
> *Personal Journal,* not numbered

Riddell was never completely clear in his writing exactly what he meant by gravitation. In some cases he refers to the "velocity of gravitation" as the "velocity of waves or impulses in a medium" and in others refers to gravity as proportional to the cube of the

diameter of a falling particle. He set up his own symbolic relationship for the size of particles, which he used on many occasions:

m = a sensible portion of common matter
θ = a fraction of unity, indefinitely small
$m\theta$ = an expression for the weight of a particle of common matter
$m\theta^2$ = an expression for the weight of a particle of luminiferous ether
$m\theta^3$ = an expression for the weight of a particle of gravitation-bearing ether.

Personal Journal, not numbered

A curious bit of speculation was his term "mass of motion" defined as

> "the product of the weight of a moving body and the space moved through."
>
> *Personal Journal,* vol. 19

Riddell illustrated the term by the following example:

> "If 100 pounds of lead move one rod, the mass of motion is 10."
>
> *Personal Journal,* vol. 19

Riddell used this idea to demonstrate the fallacy of plans for perpetual motion. Later he admitted that the term was incorrect, that he was confusing momentum with "mass of motion."

In connection with the Davidson aerial navigation controversy he devised a convenient method to calculate the force necessarily exerted in flight to sustain a bird from falling, provided the weight of the bird (in pounds) and the area of its wings are given. His calculation is as follows:

> "Multiply weight in pounds by 71.08, divide by the area of wings in square feet. Take square root. Multiply the root by the weight of the bird in pounds, then by 0.152. This will be the number of pounds raised 1 ft/sec expressive of the force exerted."
>
> *Personal Journal,* not numbered

As early as November 15, 1835, Riddell expressed his ideas on attraction and repulsion.

> "I will note down some of my crude incipient opinions on the subject of attraction and repulsion. Let me suppose that repulsion is caused by ethereal matter as caloric; that the amount of repulsive force is in direct proportion to the quantity of ethereal matter among ponderable particles. Let the body to be contemplated be a gallon of air in a glass bottle. Now if this air be so compressed that the distance from one aerial particle to its neighbour be reduced ½ (½x½x½ = 1/8) the air would be contained in a pint measure, there would be only 1/8 the previous volume and supposing no ethereal matter to be lost it will be eight times as dense as in the commencement, therefore the repulsion will be eight times as strong. This accords with fact."
>
> *Personal Journal,* vol. 14

There were occasions when Riddell attempted to refute a body's attraction for another. His original radiant theory of gravitation could be interpreted to show that the sun would repel the earth, but he modified his thinking to take care of this situation.

In another statement on falling bodies:

> "Bodies falling in the air acquire a certain maximum of velocity, which depends upon their size and density. The resistance they meet with is in proportion to the square of their diameter. (I suppose them globular). The forces of gravity, in proportion to the cubes of their diameters. They acquire their maximum of velocity when the resistance equals the gravity."
>
> *Repository,* vol. 6

Riddell's views on capillarity were not as sound as some of his other theories. He recognized the correct formulation of the law of capillary rise, but when he applied capillarity to living systems he was not correct. His statement of the basic law is:

> "... multiply the diameter of a known tube by the height at which the liquid stands, and divide the product by the height of the required tube. This will afford a very accurate mode of measuring the capacity of capillary tubes of glass."
>
> *Personal Journal,* vol. 4

On another occasion he wrote:

> "The sun, I have no doubt, as well as the moon, must have some influence on the absolute weight of bodies on the earth's surface."
>
> *Personal Journal,* vol. 12

He then estimated the influence that the sun exerts on a corpuscle of matter on the earth's surface, and constructed a "gravimeter" to study capillary action.

XIV. NEW ORLEANS – 1846-1850

Riddell's introductory lecture at the University of Louisiana in 1846 was published as a "Brief sketch of subjects embraced in the science of botany, with its relation to medicine, and some of the inducements for

engaging in its study." This article was frequently referred to as "Medical Botany." The Professor told his students

> "that he had taken some pains to determine the number of species indigenous to Louisiana and that including all yet observed by Darby, Robin, Bartram, Teinturier, Drummond, Dr. Hale, Professor Carpenter and himself, he had listed about 1000 different species."
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 2, pp. 445-449

He urged them to form their own herbaria:

> "Collect . . . specimens in flower of the different wild herbs you meet with, and dry them by pressing them between many thicknesses of brown paper, or old newspapers. Arrange these specimens in a book or otherwise, and if you are not skillful enough to affix the right names to accompanying labels, get some competent botanist to name them for you.
>
> *New Orleans Medical and Surgical Journal,* 1846, vol. 2, pp. 445-449

This is reminiscent of Riddell's earlier years when, in anticipation of a private medical practice, he had collected and dried various herbs and the roots of medicinal plants.

Riddell's marriage to Angelica Eugenia Brown was solemnized December 1, 1846. The marriage contract was passed before Daniel J. Ricord, notary, on November 13, 1846. The couple had eight children:

Lephe Eugenia	– born April 3, 1848
Mary Angelica	– born February 14, 1850
Susan Adelaide	– born October 29, 1851
Gaen Leonard	– born November 25, 1853
Robert Brown	– born December 8, 1853
Peter Gates	– born January 13, 1858
Jefferson Davis	– born October 29, 1861
Hugh Gawn	– born June 18, 1865

It is not pertinent to this work to trace the lives of each of the children. A few random observations must suffice. Gaen Leonard died in New Orleans, February 12, 1858. Lephe Eugenia married York A. Woodward of New Orleans, and died September 25, 1902. Mary Angelica married Robert F. Hogsett of New Orleans, and died December 1, 1870. Peter Gates married Louise Jehle, and died about 1912. The exact dates of death and marriages of the remaining children have not been located.

After the birth of his daughter Lephe in 1848 Riddell purchased a home in Carrollton, Louisiana, now a part of New Orleans, moving there from the Mint. He left his brother George, who had received his Doctor of Medicine degree from the University of Louisiana.

> "to perform my duties as melter and refiner in the Mint."
>
> *Personal Journal,* not numbered

He lived in Carrollton only a few months, but returned there in March, 1849.

> "In December, 1848 I was removed from office in the Mint, through some Creole manouevers, alleging that I neglected my duties and incompatibly held a state office (Professor in the University of Louisiana). I never could get at any other charge. I settled up my accounts fair and square at the end of the year (1848) and retired from the Mint. My brother and his wife returned to the North, Oxford, Chenango Co., N.Y."
>
> *Personal Journal,* not numbered

In a letter to Dr. George Engelmann, March 31, 1849, Riddell wrote:

> "Having no longer any office in the Mint, which for years has absorbed so much of my time, I propose again to devote some attention to botany. I will endeavor sooner or later to requite some favors I have received at your hands. But I beg you will for the present allow me to become still deeper in your debt. I am desirous of getting your published memoirs on the plants of Texas, especially those collected by Lindheimer. If you cannot send me copies by mail, pray inform me what volume of what transactions to send for, as containing them.
>
> "I must have on hand many duplicates of Southern plants, some of which may be acceptable to you, at least as material for further exchanges. If you say so, when I overhaul them, I will lay you aside a parcel.
>
> "Any of your own memoirs on botany will be to me acceptable. . ."
>
> Engelmann letters, Missouri Botanical Garden, St. Louis, Missouri
>
> March 31, 1849

XV. NEW ORLEANS – 1850-1860

With additional time to devote to his scientific activities Riddell entered a new phase of his work. From 1850-1855 he did some of his best scientific work, principally the invention of the binocular microscope. Despite the unfortunate publicity which accompanied most of his controversies at the Branch Mint, and his scientific exchanges, he

was much in demand as a lecturer and as a writer.

Riddell was a charter member of the American Association for the Advancement of Science (1848) and attended the Cleveland meeting (1853) as a representative of the New Orleans Academy of Sciences. He presented four papers on that occasion.

He was also a charter member of the original Louisiana State Medical Society (1849) and was chairman of its committee "on the indigenous botany of the state and its materia medica." Riddell continued his teaching in the Medical Department of the University of Louisiana, with the new title "Professor of Chemistry and Materia Medica."

Not too many details about Riddell's academic life have been recorded. It is known that he was not very well liked by his associates on the medical faculty. This follows logically from his temperament and his sarcastic and often bitter attacks on individuals. On one occasion he antagonized his fellow faculty members so much that he was relieved of his position, but he declined to resign. He was reinstated, after lengthy reconsideration, some time later. On another occasion when he was ill he allowed his brother William Pitt Riddell to lecture in his place. William, then a student in the Medical Department of the University, was a graduate in chemistry from Yale University. Unfortunately he was heard lecturing by the Dean of the Medical Department. The Dean became quite excited, and reprimanded John Leonard. But at a subsequent faculty meeting he defended his brother William staunchly. William became a member of the faculty of the Collegiate Department of the University of Louisiana at a later date.

During the early fifties Professor Riddell was engaged in the development of his binocular microscope, probably his most outstanding contribution to science. The instrument was described in a talk before the Physico-Medical Society of New Orleans on October 2, 1852, and was reported at the Cleveland, Ohio, meeting of the American Association for the Advancement of Science in 1853. This development followed several years of microscopic work for which Riddell used a Spencer instrument.

During the summer of 1853, Dr. Riddell and his son Sanford traveled by boat to New York, by way of Havana, Cuba. Sanford spent a good portion of each year in New York State with his grandmother and other relatives.

Later in 1853, Riddell and his brother William made several inspection trips for the Sanitary Commission of New Orleans. The Sanitary Commission, composed of A. D. Crossman, Mayor of New Orleans; Dr. Edward Hall Barton, chairman; Dr. A. F. Axson, Dr. J. C. Simonds, Dr. S. D. McNeil and Dr. John Leonard Riddell, was authorized to report on the causes and prevention of yellow fever, as well as the extent of the 1853 epidemic. The Riddell brothers journeyed to Lake Providence, Louisiana, and to Vicksburg, Mississippi, to survey conditions in these regions. A formal report of the Commission, largely written by Dr. Barton, was prepared and published in 1854. Riddell did not agree with all of the opinions expressed in the report, and so stated publicly in lectures and articles.

The relationship between William and John Leonard serves to illustrate another facet of Professor Riddell's personality. His strong love for his family, as noted during the days of his wanderings, increased as he became an established professor and scientist. As was noted in another section, two of his brothers were employed, at least for a brief time, at the Branch Mint. John Leonard had sent William money for his education on many occasions, so that it was natural for William to come to New Orleans after his graduation from Yale University. William always held John Leonard in the highest regard, and their relationship was always on a friendly basis. The brothers maintained a commercial laboratory of analytical chemistry, and advertised in the local newspapers and journals. On the front cover of the *New Orleans Monthly Medical Register* for April, 1853, we find the following:

> "Chemical Analyses and Chemico-Microscopic Examinations of Waters, Ores, Natural, Morbid and Manufactured Products.
>
> "Assay of Ore $10
> Assay of gold or silver bullion $5
> Assay of Soil $25-50

White Sugar or Cane Juice	$5
Molasses or Brown Sugar	$7½
Mineral Water (qual)	$10-25
Mineral Water (quant)	$50-100
Urine (Microscopic and Chemical)	$5

Many analyses were published, notably those of mineral springs, "wheat flower" and soda water.

The selection of William Pitt Riddell as a member of the faculty of Jefferson College, St. James Parish, Louisiana, and later as a member of the faculty of the University of Louisiana was influenced, no doubt, by John Leonard's prestige in the community. William, however, was a very capable chemist in his own right. He noted in his diary that he thought his brother (John Leonard) would be appointed president of the University of Louisiana (1855) but this did not materialize.

William prepared the genealogy of the Riddell Family, referred to earlier, which was brought to New York for publication by his brother. The manuscript was placed in the hands of John F. Trow, said to be the best printer in New York City (1852).

John Leonard sent sons Sanford and Edward Henry to Jefferson College in care of brother William (1853) and visited them on several occasions.

One of the few illustrations of the kindly, paternal side of Riddell is given in the following letter to his son Edward Henry:

Univ. La., New Orleans, Oct. 14, 1853

"Dear Son,

I was glad to receive your letter dated Oct. 2. You seem to be doing well. I am sorry you do not spell better. In order to become a good speller you must get into the habit of reading books which interest you; and you must inquire of Sanford, the meaning of words, or look them out in a dictionary. Your letter, however, looks remarkably well and business like, and I am proud to receive it. I have great confidence that both you and Sanford will do well.

"Keep yourselves clean, tidy, dry and warm. Keep your hair and teeth clean. Wash your teeth well with a brush at least once a day, say in the morning when you first get [up]. Do no mean action. We are all well here.

From your father,
J. L. Riddell

To Edward H. Riddell

This letter was part of the Frederic J. Grant collection of Riddell philatelic materials, and was sold at auction in 1959. The purchasers, Raymond and Roger Weill of New Orleans, kindly permitted the author to copy the letter.

Professor Riddell gave at least two public lectures at the Mechanics Institute each year. Not all of these were based on new material, for one of his old favorites, "On the chemistry of the atmosphere" was programmed March 2, 1854. On one occasion the local press commented:

> "The interest naturally attending the subject was heightened by the lucid and almost brilliant illustrations of the learned Professor and his manner of presenting it added laurels to his previously well-earned fame."

This extract, undated and with subject unknown, is found in brother William's diary.

Riddell, the business man, expanded his interests in 1854, purchasing some property near Amite, Louisiana and some near Chatawa, Mississippi. The Chatawa property served as a vacation home for the Riddells and their families and friends for many years. William wrote that the

> ". . . distance from Brother John's place to the state line is five miles."
>
> W. P. Riddell, *Diary*

Riddell prepared a technical report in 1854 on the subject of city sewerage for the Sanitary Commission, and presented it to the municipal authorities. He gave a detailed plan for the improvement of the sewerage system, including scale drawings, locations of major pipes, joints, etc.

Dr. Riddell was one of the founding members of the New Orleans Academy of Sciences in 1853. He was not one of the original group who established the society, but, by vote of the original members, on May 9, 1853, he was elected to the Academy and included as a Charter Fellow along with eight other scientists of the city. He duly subscribed to the Constitution of the Academy on May 10, 1853. It is curious to note that his brother William was a Fellow of the Academy before his more distinguished elder brother. As would be expected, Dr. John Leonard Riddell took a very active part in

the new society. One of its early meetings, May 23, 1853, was held in his home. He was appointed, along with Dr. Edward Hall Barton and Caleb G. Forshey, to represent the Academy at the 1853 meeting of the American Association for the Advancement of Science. He was also a member of the Academy Committee on Publications and presented copies of his "Monograph of the Silver Dollar" and "Report on the Epidemic of 1853" to the Academy on March 6, 1854. He demonstrated his binocular microscope before the Academy on March 27, 1854.

Most of Riddell's activities in the New Orleans Academy of Sciences were of a scientific nature, with full participation in all discussions on all topics. He demonstrated his paraboloid objective, refuted Dr. Edward Hall Barton's theory of the cause of epidemics, ridiculed Dr. Isaac Crawcour's papers on chemistry, and urged the Academy to participate in balloon ascensions. On one occasion (February 19, 1855) Riddell commented on a paper by Dr. William B. Lindsay as follows:

> "Having himself been accustomed in early life to the labors of the farm, he was practically familiar with the cultivation of cereal crops, as practiced in the cold States of the North, where the industry of six or seven months of the warmer season is demanded to provide sustenance for the remainder of the year; but he had no experimental knowledge of the raising of vegetables, etc. in this mild climate. Any person experienced in housekeeping in New Orleans can testify to its extraordinary expensiveness. When the common potato is sold, as it is now, at the rate of two for five cents, he thought it high time for us to endeavor to devise some cheaper means of obtaining that very essential article of vegetable diet."
>
> New Orleans Academy of Sciences, *Minutes,* February 19, 1855

From the remarks noted by the excellent secretary of the Academy, Dr. Noah B. Benedict, Riddell's phraseology on many occasions was sarcastically polite, nothing more, and it is small wonder that he was not popular among his colleagues. He was indeed a man of strong convictions, and anyone disagreeing with him would feel his verbal sting.

Riddell was elected vice-president of the New Orleans Academy of Sciences in 1854, and president in 1855. He was re-elected annually and was still serving as president at the time of his death in 1865. From some of the discussions in the Academy minutes we wonder whether Riddell's popularity in that organization might be due to the fact that those who opposed him either died or left New Orleans during the early years of the Society, and, since there was a blackball system for new members, only those who were friendly to Riddell constituted the Society.

It was the policy of the Academy to have the president read an Annual Address at a public gathering in February of each year. These occasions gave Riddell an opportunity to demonstrate his extraordinary abilities as a lecturer, and we find several of these speeches printed in pamphlet form, and also carried by the local press. For, example, the February 25, 1856, lecture appeared in the New Orleans *Sunday Delta,* and also as a pamphlet. It is a remarkably good resume of scientific activities of the year 1855-1856, citing developments in astronomy, geography, metallurgy, chemistry, physics, botany and geology, with remarks about the circulation of blood and the atmosphere.

In 1855, Riddell was appointed a member of a new Committee to devise protection for New Orleans from flood waters of the Mississippi River. This followed a series of severe crevasses which had threatened the city for several years. Others serving with him were W. S. Campbell, A. D. Crossman, H. J. Ranney, and J. C. Clarke.

Dr. Riddell was seated in a third floor room of his home at #328 Camp Street, when a lightning flash struck the building during a thunderstorm (1857). His dog, which was on the floor between his feet, was killed by the bolt. Riddell described the experience as a

> "sudden intense glare of light, and fragments of wood, bricks and plaster flying in all directions. Heard no sound whatever. Was conscious of no clap, noise or concussion of any kind, but felt as if he had received a great blow on the top of his head."
>
> New Orleans Academy of Sciences, *Minutes,* January 5, 1857

One of Riddell's pet projects, the Geological Survey of the State of Louisiana, was revived by the New Orleans Academy of Sciences in 1855. He was, naturally, a member of the Committee memorializing the Legislature of the State of Louisiana. The project did not meet with as much enthusiasm and approval in the Legislature as was hoped and actually the complete survey was never made. A partial survey appeared after Riddell's death.

Because of his geological interests, Riddell was one of the prime movers in an attempt to drill an artesian well in the center of Canal Street, main business thoroughfare in New Orleans. This project, sponsored by the New Orleans Academy of Sciences, was undertaken in 1855, following Riddell's recommendation that the well would produce "potable mineral water." The attempt was a dismal failure, although Riddell contended that the project was never carried to completion, but abandoned. This was actually correct for the appropriation was exhausted and additional funds were not forthcoming.

XVI. SCIENTIFIC ACHIEVEMENTS – 1850-1855

This was the most productive period of Riddell's life. A brief summary of some of his more important investigations is given here.

The Binocular Microscope

In the field of optics, Riddell's outstanding contribution was his binocular microscope. His interest in microscopy began with his first purchase of a Spencer instrument in 1850.

> "... it is now fairly conceded that Spencer, though an American, has considerably excelled the best English and European opticians in this most difficult department of practical optics.
>
> "... observations were made with a glass of exquisite workmanship, one of Spencer's latest and best productions. I gave him an order for the finest objective of high power which he could make, expressly without limit as to price. He sent me the instrument ... in May, 1852 writing me at the same time that it was the best he had ever made, and charging me for it, what I consider a most moderate sum, $120; for its defining power is so great and so wonderfully accurate, that a sum of money greater than I choose to name, would not deprive me of its possession. It is rated by Spencer as 1/16 of an inch focus, though the available working focal distance is probably less than 1/200 of an inch, requiring the very thinnest of Chance's thin glass, for covering objects to be seen. Its angle of aperture is full 174°! a figure at least 40 units beyond what the best Eurpoean opticians have, until quite lately, considered practicable ... That most difficult test object, the *Grammatophora sublitissima* of Bailey, is, by this glass, readily and clearly resolved into black, beaded lines."
>
> *New Orleans Medical and Surgical Journal,* 1852, vol. 9, p. 119

There followed a series of thorough microscopic investigations, with several papers published between 1850 and 1854.

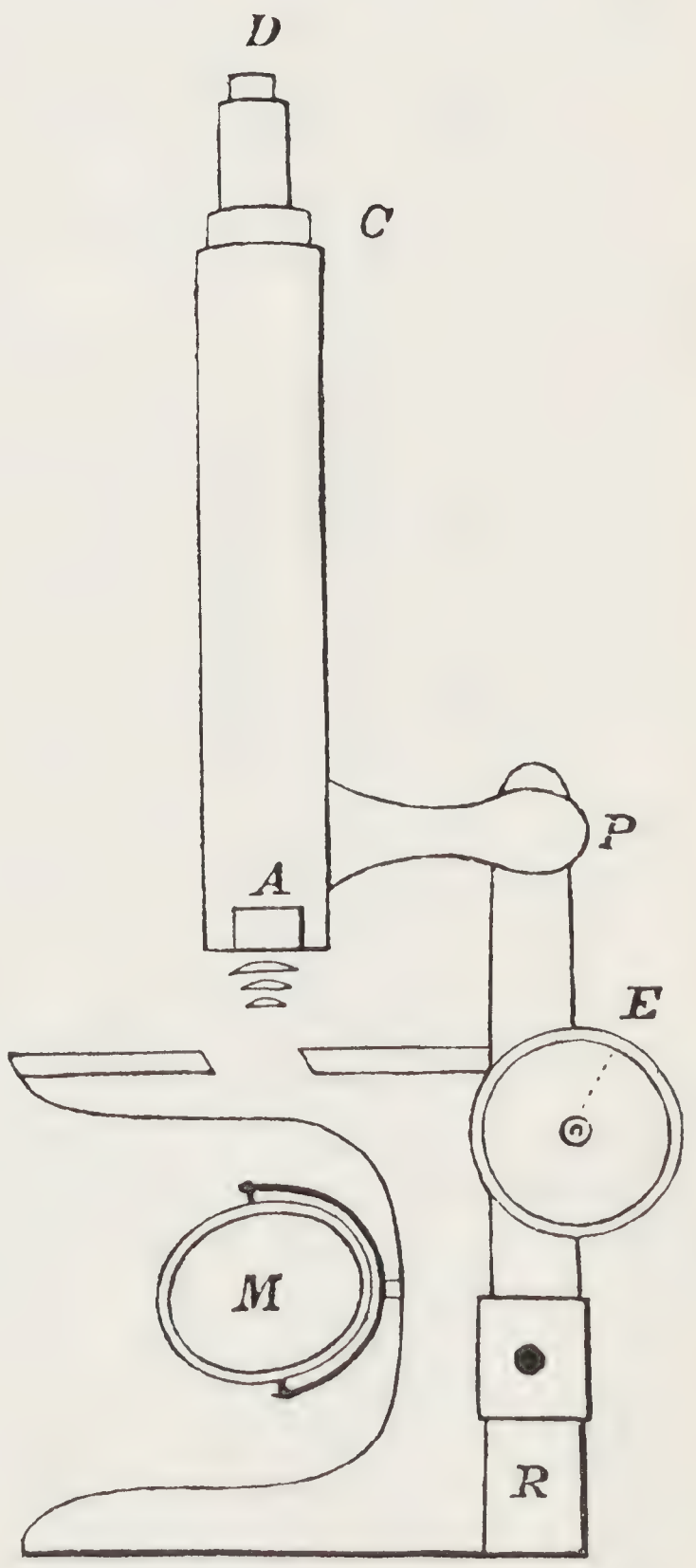


Figure 6. Side view of Riddell's binocular microscope (from *Proceedings, American Association for the Advancement of Science,* 1853, vol. 7, p. 20).

The binocular microscope was designed in 1851, constructed and tested during 1852, and formally reported to the New Orleans Physico-Medical Society on October 2, 1852. In principle, it divided light from a single objective by means of a combination of four glass prisms, passing the light beams to the eyes through two parallel tubes, each having its own ocular. The account of the meeting of the Physico-Medical Society was reported in the *New Orleans Monthly Medical Register* for October, 1852, and was probably written by Riddell. The basic principle is stated:

> "Behind the objective, and as near thereto as practicable, the light is equally divided, and bent at right angles, and made to travel in opposite directions, by means of two rectangular prisms which are in contact by their edges, that are somewhat ground away. The reflected rays are received at a proper distance for binocular vision upon two other rectangular prisms, and again bent at right angles; being thus either completely inverted, for an inverted microscope, or restored to their original direction. These outer prisms may be cemented to the inner, by means of Canada balsam; or left free to admit of adjustment to suit different observers. Prisms of other form, with due arrangement, may be substituted.
>
> *New Orleans Monthly Medical Register,* 1852, vol. 2, p. 4

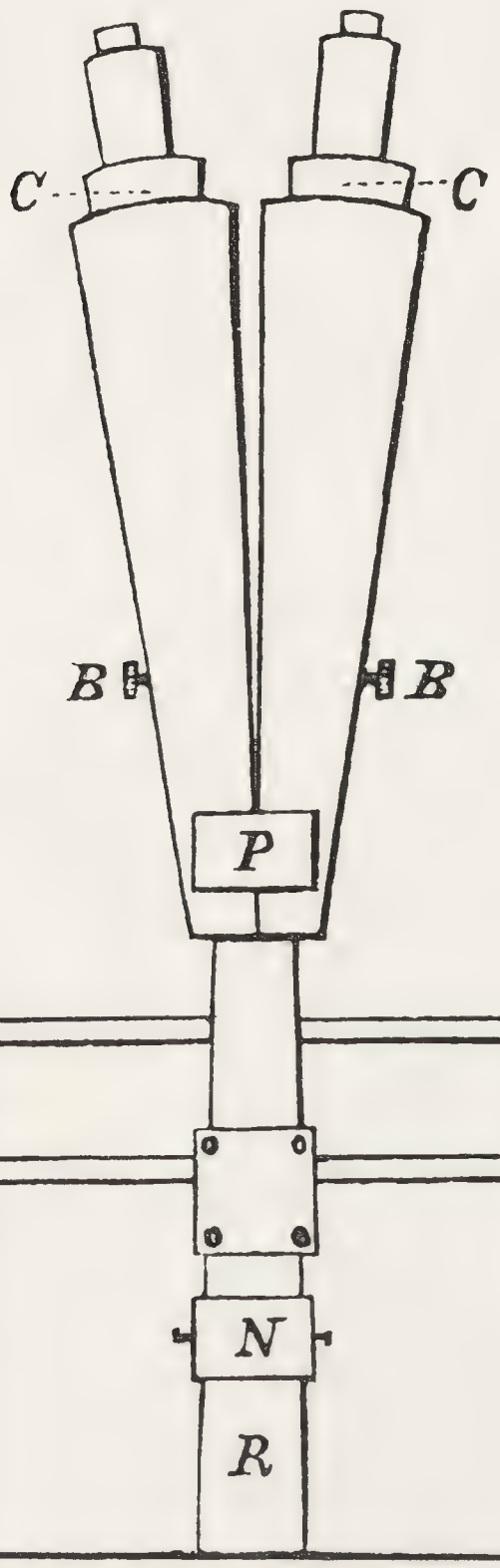


Figure 7. Back view of Riddell's binocular microscope (from *Proceedings, American Association for the Advancement of Science,* 1853, vol. 7, p. 20).

The original instrument was described before the Cleveland meeting of the American Association for the Advancement of Science on July 30, 1853. In Riddell's own words, and referring to this diagram,

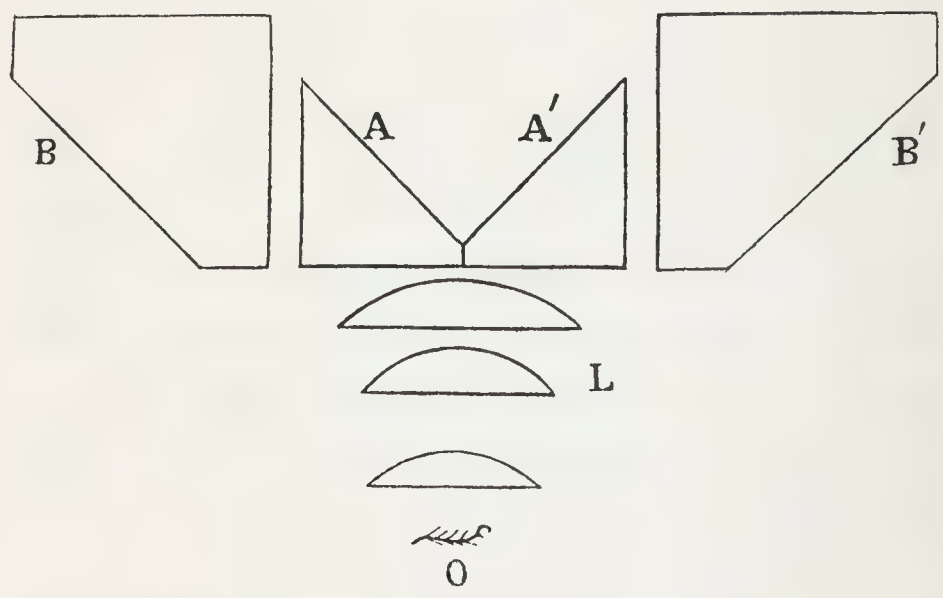


Figure 8. Diagram of Riddell's binocular microscope (from *Proceedings, American Association for the Advancement of Sciences,* 1853, vol. 7, p. 16).

"O represents object to be seen.
L the objective combination; always brought as near as practicable to the prisms.
A,A' two isosceles rectangular prisms of fine glass, in contact by the edges, which are somewhat ground away.

"The light entering the prism A through the objective, suffers internal reflection on the hypothenuse A, and emerges from the prism in the direction of B. Entering the prism B it is restored to its original direction. So likewise that part of the luminous pencil entering the prism A' emerges nearly parallel from the prism B'. The prisms B and B' are adjustable to different distances apart, and have likewise an axial adjustment in the plane of the section represented; the first, that they may be made to correspond to the interval between the two eyes of the observer; the second, that the direction of the rays travelling from each point of the object through these prisms, may be such as will seem to the observer natural

and unconstrained and give clear, coincident fields."

Proceedings, American Association for the Advancement of Science, 1853, vol. 7, p. 17

This instrument could be used with or without oculars or erecting eye-pieces, and with all grades of good lenses. Riddell stressed that a true stereoscopic effect was always obtained.

> "It gives the observer perfectly correct views in length, breadth and depth, whatever power he may employ; objects are seen holding their true relative positions, and wearing their real shapes. . ."
>
> *New Orleans Monthly Medical Register,* 1852, vol. 2, p. 4

He did admit, however, that

> "In looking at solid bodies, however, depressions sometimes appear as elevations, and vice versa, forming a curious illusion. . ."
>
> *New Orleans Monthly Medical Register,* 1852, vol. 2, p. 4

The original instrument was quickly modified to eliminate the pseudoscopic effect. This was reported to the New Orleans Physico-Medical Society, April 2, 1853.

> "Professor Riddell, the original inventor of the binocular microscope, exhibited and explained a simplification of that important instrument by which, at an expense not necessarily exceeding thirty or forty dollars, it is practicable, in existing compound microscopes of the ordinary forms, to replace the brass tube carrying the ocular and objective, by an efficient arrangement for binocular vision."
>
> *New Orleans Monthly Medical Register,* 1853, vol. 2, p. 78

Only two forty-five degree French prisms were used in the modified instrument:

> "They must be of such form, that the faces, at which the light is immergent and emergent, shall form equal angles with the face on which the internal reflection occurs. The chromatic dispersion is a minimum, and really nothing, when these angles are each near eighty-seven degrees . . . To produce orthoscopic binocular vision, simple, not erecting eye-pieces are required."
>
> *New Orleans Monthly Medical Register,* 1853, vol. 2, p. 78

The modification was also reported to the *Quarterly Journal of Microscopical Science* and to the American Association for the Advancement of Science.

In his paper at the 1853 meeting of the American Association for the Advancement of Science Riddell noted that the instrument could be used as a dissecting microscope, if the focal length of the objective lens was ½-3 inches, and no eyepiece used.

> "The image is erect and orthoscopic . . . If over B and B' (see previous diagram) single oculars be placed, the binocular vision is found to be pseudoscopic; that is, depressions appear as elevations, and elevations as depressions. With erecting or double eyepieces, analogous to the terrestrial telescope, the vision again becomes orthoscopic."
>
> *Proceedings, American Association for the Advancement of Science,* 1853, vol. 7, p. 17

Riddell's design of a compound binocular microscope is also given in his 1853 paper. Using the sketch from that paper

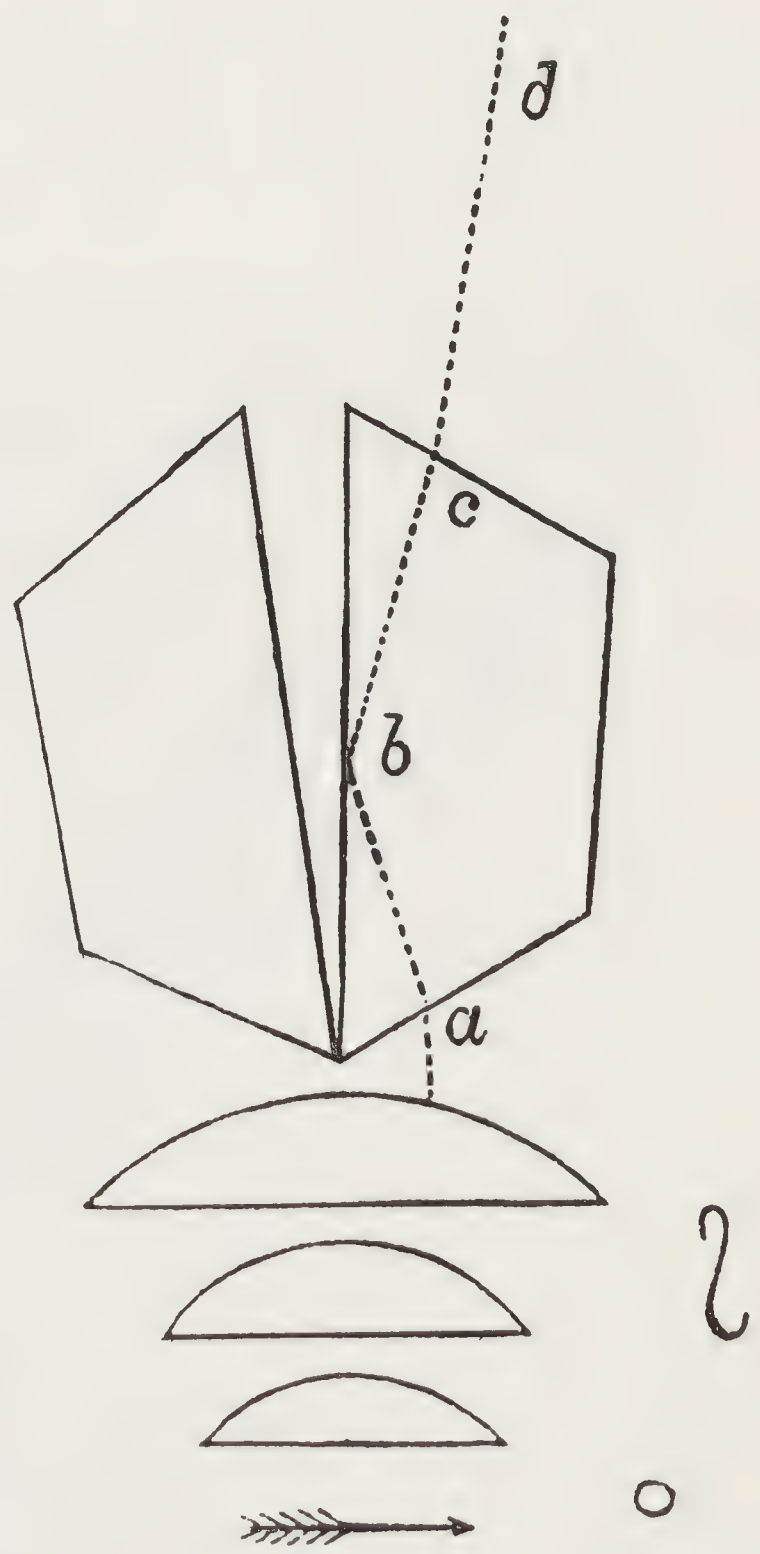


Figure 9. Arrangement of prisms above the objective in Riddell's binocular microscope (from *Proceedings, American Association for the Advancement of Science,* 1853, vol. 7, p. 18).

> "The light through the objective, which impinges upon a is, that part of it which enters the prism refracted to the left, so that it meets with the reflecting surface b. Suffering total reflection, it emerges from the surface c, where, from the necessary identity of the immergent and emergent angles, it is refracted to the left**, so as to exactly compensate for its previous refraction to the left. This implies that the upper and lower angles of the prism are equal."
>
> *Proceedings, American Association for the Advancement of Science,* 1853, vol. 7, pp. 18-19

An instrument of this design, constructed for Riddell by the Grunow Brothers of New Haven, Connecticut in 1854, was presented to the United States Army Medical Museum, Washington, D.C. in April, 1879, by Mrs. Angelica Riddell. In this model, which is upright, the two tubes are adjustable at either end,

> "so that their inclination to each other may be varied; and the whole arrangement slides at pleasure, horizontally, in order to adapt the distance to the eyes of different observers."
>
> *Proceedings, American Association for the Advancement of Science,* 1853, vol. 7, pp. 20-21

The angle of the prisms is also adjustable. With this instrument

> ". . . microscopic objects . . . seemingly hung in mid-air, stand out in all the boldness and perfection of relief and with definiteness of position in width and depth, which he has been accustomed to realize without glasses, in the natural objects around him."
>
> "Opaque objects may be illuminated by the bull's eye condenser; and transparent objects by two concave mirrors, aided by two diaphragms . . . or one large concave mirror and two screws. At night, two candles may be used conveniently with one mirror. To illuminate for the higher powers, a single achromatic condenser suffices."
>
> *Proceedings, American Association for the Advancement of Science* 1853, vol. 7, pp. 21-22

**The word "left" is incorrect, and should be "right". A similar article in the *New Orleans Medical and Surgical Journal* has "right".

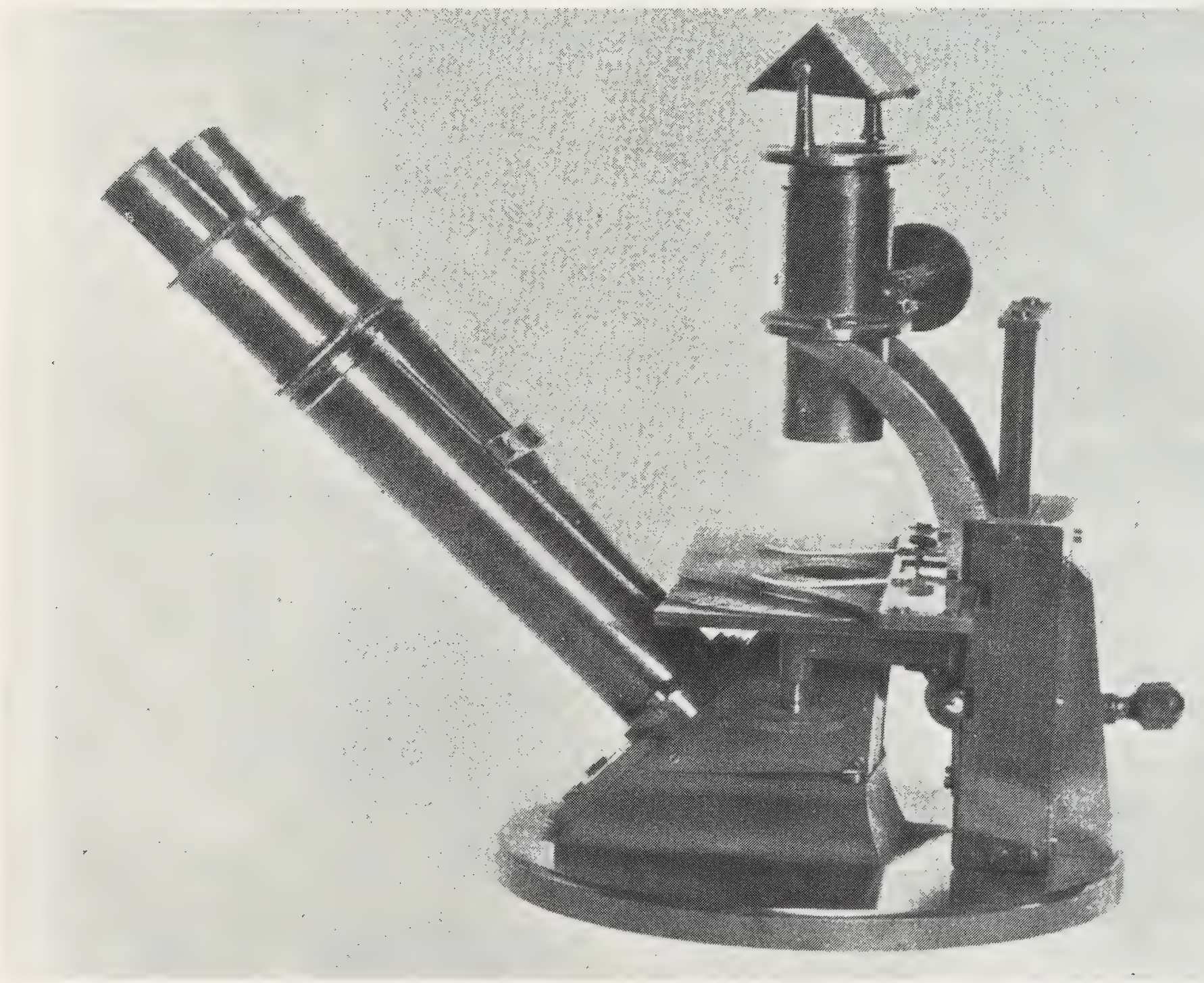


Figure 10. Riddell's binocular microscope (United States Army Medical Museum).

The museum instrument was described, with quotations from Riddell's papers, by Dr. J. J. Woodward in the *American Monthly Microscopical Journal* (1880) and reprinted in the *New Orleans Medical and Surgical Journal* (1881). There are numerous errors in the quotations in Woodward's papers.

Professor Riddell demonstrated his binocular microscope before the New Orleans Academy of Sciences on March 27, 1854. The Academy minutes note that

> "it is orthoscopic as to form, position and motions of objects under examination."
>
> New Orleans Academy of Sciences, *Minutes*

A committee, composed of Dr. Josiah Hale, Dr. Isaac Crawcour and Thomas Cerre Copes, was appointed to examine the microscope and report on its claims. The committee, reporting April 13, 1854, announced that they

> "unanimously concor in regarding Professor Riddell's invention—the binocular microscope—as supplying a great desideratum in microscopy. It gives correctly a third dimension to the visual field in that instrument, namely depth . . . (They) look upon it as a complete triumph."
>
> New Orleans Academy of Sciences, *Minutes*

The price of the instrument is given as $150.00.

Riddell's discovery of the principle of the binocular microscope has been erroneously credited to others. However, such early authorities as Pieter Harting (1866) and Heinrich Frey (1873) recognize Riddell's contribution.

> "Dem Nordamerikaner Professor Riddell gebuhrt das Verdienst, zuerst den wahren Weg angegeben zu haben, den man zur Erreichung dieses Zieles einzuschlagen hat."
>
> P. Harting, *Das Mikroskop,* 1866

> "Einem Amerikaner, Riddell, verdankt man die Herstellung der ersten Instrumente dieser Art."
>
> H. Frey, *Das Mikroskop,* 1873

However, Dr. William B. Carpenter, writing in 1875, fails to give Riddell credit, and indicates that M. Nachet of Paris solved the problem of stereoscopic vision. Actually, as Dr. J. J. Woodward points out, Harting had read Riddell's article, and called it to Nachet's attention. Nachet was already familiar with Riddell's basic design, but did make some modifications and did construct an instrument. Likewise no credit has been given Riddell by J. W. Stephenson who constructed an "erecting binocular microscope." Actually Stephenson's instrument is, in optical sense, Riddell's modified design. Stephenson did make some later changes which are beneficial to the design, but these in no way alter the basic principle, which is definitely Riddell's. Perhaps the British failure to recognize Riddell was due in part to the attitude of Professor Charles Wheatstone. Wheatstone had written on the subject of a binocular microscope and stereoscopic vision, but several months after Riddell's work had been published. He read Riddell's paper, and announced

> "The method Mr. Riddell employs is similar to the one I recommended to Mr. Beck."

But no instrument was made in England at that time.

In addition to the binocular microscope Riddell constructed a special achromatic and aplanatic object glass for a telescope which he described:

> "The front or terminal combination of the objective is made to condense light upon the opake object, by sending rays of light from behind, through the marginal border of the lens. To accomplish this, a circular disk of fine plate glass, say near a fourth or fifth part as thick as the diameter of the lens, is bevelled on its outer margin, by grinding and polishing to an angle of 45 degrees. A hole is drilled through the center of the disk, of a diameter say two-third, three-fourths or four-fifths (dependent upon the angle of aperture) as great as that of the lens. The margin of this hole is also bevelled at an angle of 45 degrees, down to a clean, sharp edge. Both rings of bevels are on the same side of the glass, so that if considered as projected, the lines would cross each other at right angles. I find no insurmountable difficulty in giving an exquisite form and finish to these disks."
>
> *American Journal of Science and Arts,* 1853, vol. 15, p. 69

He also constructed an achromatic condenser:

> "A larger, thicker, similarly bevelled disk, with the bevels on opposite sides of the plate glass, and their lines of inclination coincident, would probably serve as an efficient achromatic condenser of parallel rays."
>
> *American Journal of Science and Arts,* 1853, vol. 15, p. 69

This article was written October 4, 1852, immediately after his first presentation of the binocular microscope. Since Riddell ground and polished his own lenses, we know that the workmanship and precision of his optical apparatus was of very high quality, for he would not tolerate imperfection.

A paraboloid objective was also described, which would give reflection and transmission without refraction, so that it

> "renders both spherical and chromatic aberration impossible!"
>
> New Orleans Academy of Sciences, *Minutes*

One of his later papers (February 4, 1856) was on "The binocular magnifying glass simplified for the use of naturalists and artists," given before the New Orleans Academy of Sciences. For his presidential address the same year Riddell set up a demonstration of microscopic projection, and invited the members of the Academy and the public to view it.

> "Professor Riddell exhibited and described a small lorgnette or spyglass of the Galilean construction, consisting of an achromatic object glass and a concave eye glass to which he had adapted crosshairs with the view of attaching it to the surveyor's compass. Between the eye and the concave eye glass there is placed a perforated convex lens. Through this central perforation distant objects are seen as usual, while at the same time there is obtained through the margin of the perforation of the convex lens, a distinct view of the crosshairs behind the object glass."
>
> New Orleans Academy of Sciences, *Minutes*

"Plants of Louisiana"

In 1851 Riddell prepared the *Plants of Louisiana,* a flora of Louisiana which was sent, in manuscript form, to the Smithsonian Institution, Washington, D.C., but was never published. It was not completely original, for he used some of the materials of Professor W. M. Carpenter, and the *Cypreaceae* and *Gramineae* of Dr. Josiah Hale. The work described several new species and varieties found by Riddell. It is said that the manuscript described over 2,300 species. A portion of the manuscript was published in the *New Orleans Medical and Surgical Journal* as "Catalogus florae ludovicianae," which includes the following preface:

> ". . . It comprises the technical and the vulgar names of the flowering and filicoid species of plants, well ascertained as growing within the limits of the State of Louisiana, (nearly all of which are represented by specimens in the author's herbarium), with special localities, times of flowering, and full descriptions of the new species."
>
> *New Orleans Medical and Surgical Journal,* 1852, vol. 8, pp. 743-764

This portion of the original manuscript also appeared in pamphlet form in 1852.

Dr. Clair A. Brown of Louisiana State University, in a letter to Dr. King Rand of Alexandria, Louisiana, remarked that Riddell's original manuscript was sent by the Smithsonian Institution to the Gray Herbarium at Harvard University, where the manuscript was cut up and portions pasted on the sheets of specimens which accompanied the manuscript. Brown remarked that he had seen these in the Gray herbarium collections. The same statement were published in *Fern and Fern Allies of Louisiana,* by Clair A. Brown and Donovan S. Correll. These authors list 31 species of ferns and allies in Riddell's *Catalogus.* They refer to the excellent illustrations, some in water color, accompanying some of the specimens. A photograph of Riddell's water color of *Adiantum Capillus-Veneris* is given in Brown and Correll, from one of the Gray herbarium plates. This was one of the plants Riddell found on the Texas trip, in September, 1839.

Riddell discusses his *Catalogus* in a letter to Professor Asa Gray, October 5, 1851:

> "After an interval of some years, I have again devoted some attention to botany. I have for instance this past summer prepared a list of the "Plants of Louisiana" with descriptions of some 20 or 30 of what I suppose to be new species. The manuscript is in the hands of Prof. Henry of the Smithsonian Institute—a candidate for publication. I see by your 3rd Edition of the Botanical Textbook, 1850, that you are about issuing to the world a treatise on North American forest trees. Now in the Plants of Louisiana I have venture to name no less than 5 species of *Quercus* as new, viz: *Quercus rhombifolia, bumeliaefolia, Carpenterii, Peckiana* and *Q. andromeda.* If you desire it for your publication, I will forward you a transcript of my descriptions, and all I know about them; with (at least indifferent) specimens. So far as applicable, and in my power, I have taken your publications and the *Flora* of Torrey and Gray, as standard

authority. I am sure I have not all the books on botany, indispensibly requisite up to the present time. . .

"Many duplicate specimens I still have on hand, collected many years ago, from Louisiana and Ohio. if my "Plants of Louisiana should be published, you can mark the numbers which you may desire and if practicable I shall be happy to send them to you.

"I have a kind of sneaking vanity to place in my herbarium a sample of Nuttall's *Riddelia tagetina,* of which I suppose your extensive herbarium contains duplicates. If so, send me one by letter (or mail if that is a better way of expressing it).

"Where is Nuttall? When we shall see more of Torrey and Gray *Flora of N.A.*? If you do not hurry and give us a standard work on the Flora of North America I am almost half disposed to arm myself with scissors, paste and presumptions, and get together an abbreviated Flora of N.A.—a sort of manual—something on the plan of Eaton's, or rather on the plan adopted by Beck and yourself for the Northern States.

"Were there a good general work of this sort now extant—we should more students in botany—and more local investigators would be made. . ."

J. L. Riddell to Prof. Asa Gray,
Autographs, vol. 4, p. 116,
Gray Herbarium, Harvard University

A second catalog was published in the *New Orleans Medical and Surgical Journal* a year later, entitled "New and hitherto unpublished plants of the Southwest, mostly indigenous in Louisiana."

Riddell was also making microscopic observations on diatoms and algae, principally *Closteria* and *Oscillaria aureliana,* Riddell. He sought assistance again from Dr. George Engelmann, writing:

"Can you refer me to any one in St. Louis, who devotes some attention to the *Desmidiae, Diatomaceae,* and minute fresh water algae? I should be happy to exchange specimens with some amateurs in your locality. I am particularly desirous of procuring samples of Infusorial earth, from the Western States. As you are aware, half a dozen samples can be sent in a letter, without enhancing the price of postage. To anyone desiring suits I myself can furnish from this region, a number of interesting specimens.

"I do scarcely anything now in general botany.

"You should have in St. Louis some good microscopes and microscopists, who are fond of observing living and fossil infusoria."

Engelmann letters, Missouri
Botanical Garden, St. Louis, Missouri
August 20, 1854

Unfortunately Riddell did not give complete botanical descriptions of many of his new species and varieties, so modern botanists, using the currently accepted rules of nomenclature, do not consider his findings as original or valid. An illustration of changed nomenclature is *Dyopteris Rafinesquiana,* Riddell, now *Dyopteris normalis.* Another, *Dyopteris aureliana,* Riddell, now *Dyopteris versicolor.* Both species were collected by Riddell in the marshes near New Orleans, according to Brown and Correll. Another example, *Lycopodium corallinum,* Riddell is now listed as *Selaginella Riddellii,* Van Eseltine. Riddell found one specimen of this plant in the sand hills near Kisatchie Spring, in Natchitoches Parish, Louisiana. Brown and Correll comment that

"It is fitting that this species should bear the name of one of Louisiana's pioneer scientists. It briefly commemorates a scientific career rich in achievement."

Brown and Correll, *Ferns and Fern Allies,*
Louisiana State University Press, 1942,
185 pp., Baton Rouge, Louisiana

His botanical contemporaries had high regard for Riddell's work. Nuttall assigned the name Genus *Riddellia* to a western composite. The original species was *Riddellia tagetina,* and was supplemented by *Riddellia cooperi* and *Riddellia arachnoidea.* Rafinesque established Riddell's *Melothria pendula* as a new species, and also his *Sabbatia gracilis.* Riddell exchanged plants with Nuttall for many years. Nuttall credited him with another new plant, *Bollis heterophylla* Riddell.

The Riddell specimens now in the British Museum of Natural History are handsomely bound and have labels giving the location where the plant was found, and occasionally a comment about its habits. Some of these are in Riddell's hand, others not. A few of the specimens included are *Houstonia Frankii* Riddell, *Neomophila australis* Riddell, *Punicum exile* Riddell, and *Cardamine Ludoviciana* Riddell.

Molecular Forces

Eight years after the "Constitution of Matter" Riddell wrote his "Theory of Molecular Forces." In some respects it is a duplication of some of the earlier material, but it does contain some new ideas, such as a change in his forms of matter. He postulates solids and liquids and gases now, in terms of molecular forces:

> "The molecules constituting solids, are held in a fixed relation to each other by polaric force.
>
> "In liquids the molecules are in effect held equidistant from each other, (x), by virtue of a balance between the force of molecular attraction which in reference to an invariable plane varies as $1/x^4$, usually conjoined with a subordinate influence, external pressure, acting centripetally and impingent or collisionary repulsion which varies with the temperature and also varies as $1/x^3$ conjoined with polaric repulsion acting centrifugally. Considering the polaric repulsion as added to the molecular attraction then between the limits $z = 1$ and $z = 4$, the resultant attraction varies as
>
> $$1/x^z,$$
>
> z standing for some direct and continuous function of x. (x, it is to be remembered, is his variable intermolecular distance).
>
> "In gases, the molecules occupy also equal and equidistant spaces. External pressure mainly, and molecular attraction, varying as $1/x^4$, subordinately and for the most part inappreciably, act as the centripetal forces; while impingent molecular repulsion, varying with the temperature as $1/x^3$ acts centrifugally."
>
> *New Orleans Medical and Surgical Journal,* 1854, vol. 10, pp. 446-451

In this 1854 publication Riddell makes several curious statements about attraction and repulsion:

> "Such attractions between individual molecules or bodies as vary in intensity reciprocally as the square of the intervening distance must be generally borrowed from the omnidirective impulses, which pursue their endless rectilineal paths, in the different coextensive systems of refined media, with which boundless space has ever been furnished.
>
> "The crude hypothesis, that the more simple molecules, like those of oxygen, water etc. are usually revolving on axes with intense rapidity, enables us to form a conception of the possible cause of what may be called polaric attraction and repulsion. . ."
>
> "Repulsion among gasseous particles arises from their mutual impact, occurring in the transmission of molecular momentum . . . Molecular momentum is partly identical with heat. . ."
>
> *New Orleans Medical and Surgical Journal,* 1854, vol. 10, pp. 446-451

This paper, as may be seen from the extracts, does not have the import of the earlier "Constitution of Matter", but, in fairness to Riddell, it is not worthless or insignificant. This is particularly true of the ideas of molecular spin.

Medicine—General

Since Riddell had earned the degree of Doctor of Medicine it is logical that some of his best research would be in this field. His speculations on miasm and contagion, and his microscopic work, are the best known and most important contributions of a medical nature. Some aspects of his theory of permeation are really physiological, as are his experiments on the aerial impregnation of blood.

While at Worthington (1833) he designed a "galvanic device" for dissolving stones in the bladder. It is actually a modified catheter, designed to set up an electrical inbalance within the bladder, which would cause the dissolution of the stone. There is no record that the device was successful.

Since his early training at Worthington stressed the vegetable theory of medicine, his notebooks contain references to the treatment of syphilis and gonorrhea by means of a controlled diet, with no medicine of any type being used. Likewise in the treatment of cancer, which he recognized as

> "most peculiar to old people, mostly in the mammary glands of the female-face-lips-uterus,"
>
> *Depository*

he prescribed various ointments.

Riddell did extensive reading in medicine beginning with his Ogdensburg days, and occasionally took issue with the authors. He particularly objected to Beach's *American Practice* and his *Materia Medica.* He criticized Beach's

> "leaning to empyricism and self-aggrandizement; and too much inattention to systematic

> botany and the late researches in chemistry,"
> *Personal Journal,* vol. 8

pointing out many botanical errors in the two works.

His earliest experiments in physiology concerned the aerial impregnation of blood. He attempted to ascertain the

> "truth of Mr. Dalton's views . . . by tying a string around the leg of a living cat and cutting it off in warm water that has just been boiled (hot water perhaps). Then heat the water again to near boiling and see whether bubbles of air excape . . . I am well persuaded that no air of consequence would be found."
> *Personal Journal,* vol. 10

He altered the method in his next experiment, placing the cat's leg in a bladder filled with hot water.

> "Expel all air from bladder and in its mouth tie a phial filled with hot water. By this contrivance I would prevent the blood from interfering with accurate observation, and if air were extricated from the leg upon boiling, I could collect and examine it "
> *Personal Journal,* vol. 10

He was able to find about 1/10 cubic inch of air, and also air in arterial blood, urine and saliva.

> "So I have no doubt that air pervades every permeable part of the animal system."
> *Personal Journal,* vol. 10

Several versions of the cat experiment are recorded. On one animal an analysis was made for carbon dioxide, nitrogen and oxygen in the air which he had collected.

In his capacity as a chemist Riddell was often called on to do routine testing for poisons, as well as analyzing blood and other body fluids. Riddell believed the Marsh test for arsenic to be deceptive, but regarded as

> "infallible test the experimentum crucis-after producing the dark tache, to heat it in contact with air until it sublimes, and then examine the sublimate with the microscope. If octahedral crystals, perfectly defined and brilliant as diamond are seen, we may pronounce with certainty, for they are perfectly distinctive. He (Riddell) would not testify in court without this test."
> New Orleans Academy of Sciences, *Minutes*

Occasionally a complete analysis is given in his *Journal.* Most of these routine experiments were not published.

It was not until he had purchased his new Spencer microscope and perfected his binocular microscope that Riddell began a series of microscopic observations. His series, "Selected items of observation," later called "Selected items of microscopic observation," appeared in issues of the *New Orleans Medical and Surgical Journal.* Each paper contains excellent plates drawn on stone by Riddell himself. The four articles cover the microscopic organisms found in the waters of New Orleans and vicinity, the various types of infusoriae, algae, desmids, diatoms, blood corpuscles, samples of sputa and feces from cholera and tuberculosis patients, specimens from hospital and accident cases, etc., furnished Riddell by some of the most prominent physicians in New Orleans. In addition to the drawings Riddell comments briefly on each, citing the source and conditions, and commenting on the histology of the specimen. A single article, "Microscopic observations on the blood" appears in the *New Orleans Monthly Medical Register,* and one "On the histology of red blood," in the *Proceedings of the American Association for the Advancement of Science* in 1853.

The 1853 epidemic of yellow fever was one of the worst in the history of New Orleans. Riddell was one of a group of physicians to write a report on the epidemic, which was published in New Orleans by E. LaSere in 1854. He also wrote several letters on the causes of yellow fever, and three papers on his microscopic observations in cases of yellow fever. These were:

> "Transcript of the results of microscopic observations upon black vomit."
>
> "Microscopic character of the blood and black vomit in yellow fever."
>
> "Microscopical observations pertaining to yellow fever."

A paragraph from the minutes of the New Orleans Academy of Science deals with these papers:

> ". . . Professor Riddell said that some of the matter of black vomit which has been carefully preserved by Professor James Jones was found, after a time, covered with mould; and he inquired whether any physician present had observed similar phenomena. He conjectured that the spores of those organisms

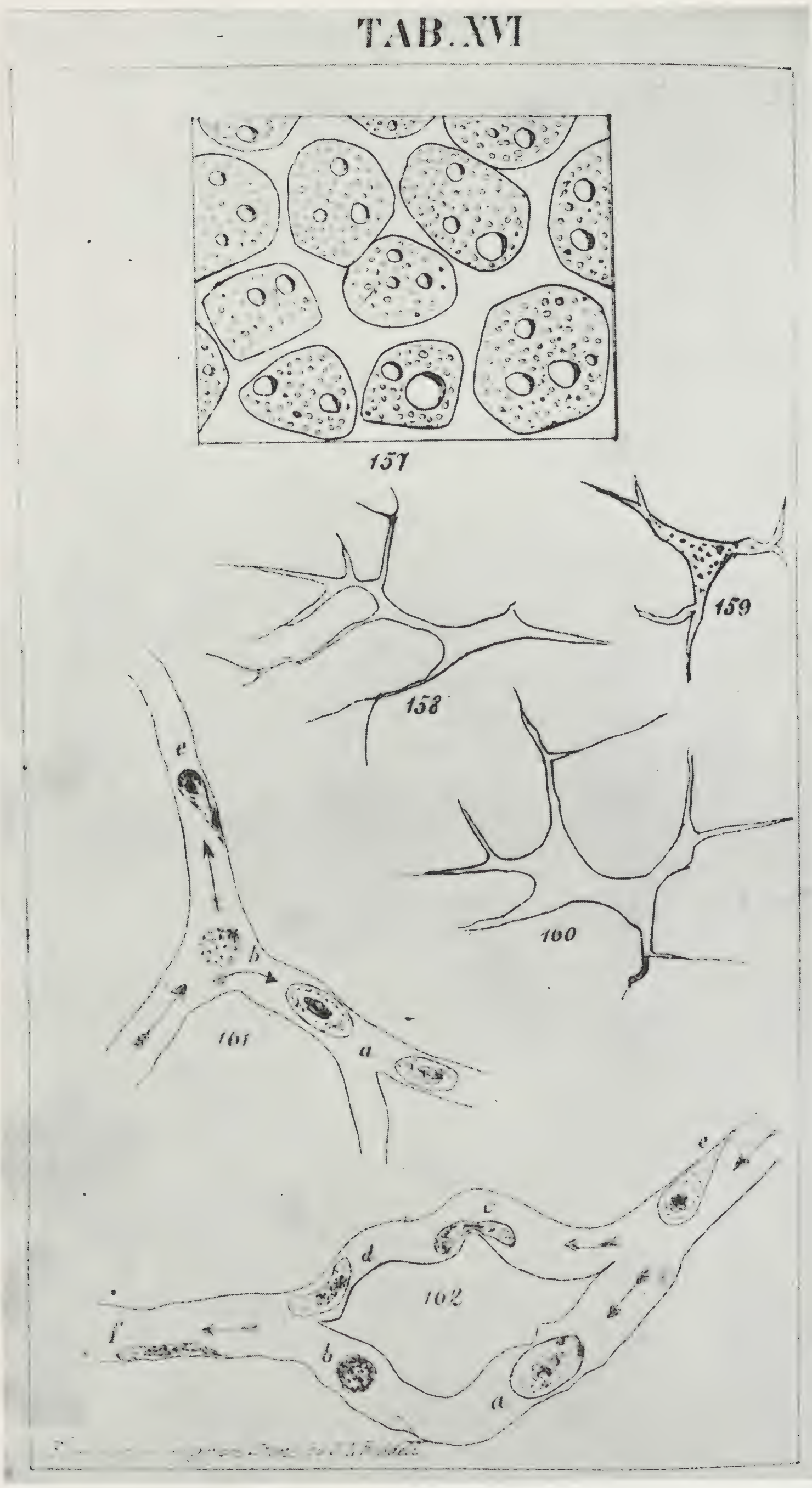


Figure 11. Microscopic observations, engraved on stone by Riddell *(New Orleans Medical and Surgical Journal,* 1852, vol. 9, p. 180/181).

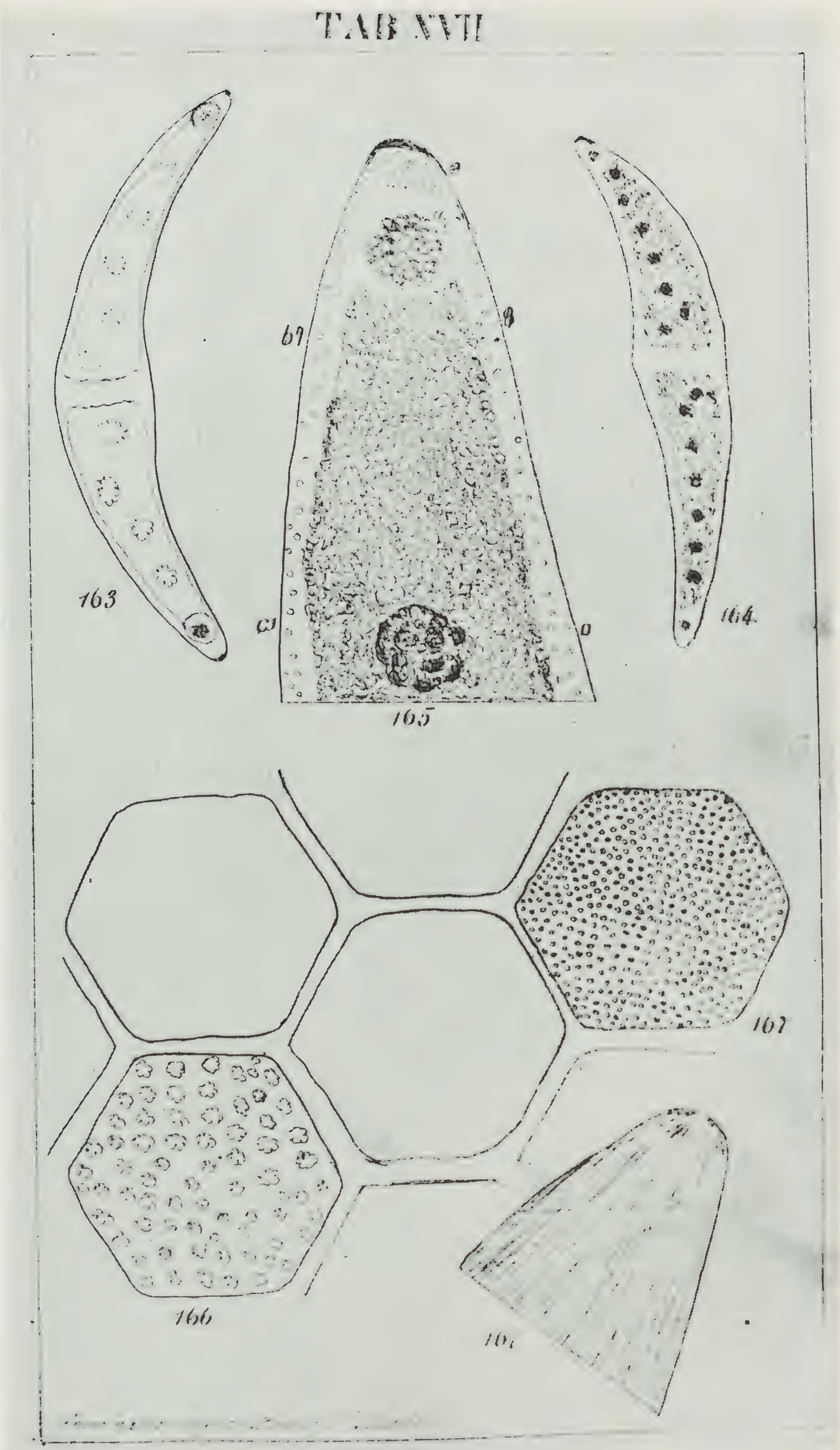


Figure 12. Microscopic observations, engraved on stone by Riddell *(New Orleans Medical and Surgical Journal,* 1852, vol. 9, p. 180/181).

> which produce yellow fever are of a kind which ripen not here but elsewhere, exposed to damp, confined air; that consequently they are brought here, not within the human body, but externally to it; and hence also the conveyance of yellow fever by fomites but not by human bodies, is readily explicable."
>
> New Orleans Academy of Sciences, *Minutes*

Thus Riddell was on the verge of the identification of the carrier of yellow fever, at least forty years before the work of Walter Reed and others.

Additional evidence of Riddell's theory of the cause of yellow fever is found in another entry in the minutes of the New Orleans Academy of Sciences, February 18, 1856. On that date Dr. Edward Hall Barton presented a paper on the "Agency of high temperature and moisture in the production of epidemic diseases." Riddell was in one of his most sarcastic moods that evening. He

> "paid a high compliment to the ability and research displayed in the paper . . . had nothing to object to the conclusions expressed as to the influence of high temperature, sudden changes of temperature, rains and terrene filth; but when the author leaves that field, to account for the production of yellow fever by a chemical formula made up of the four ingredients—solar radiation, high dew point, high temperature and terrene filth—he begged leave to declare his dissent."
>
> New Orleans Academy of Sciences, *Minutes*

He went on to illustrate his point by saying that the region of the River Ganges contains all four factors, yet no yellow fever. Dr. Barton tried to defend his paper, but Riddell, obviously enjoying the occasion, continued with

> ". . . if disease is generated by processes which are in any sense chemical, he would inquire of Dr. Barton how it happens that neither accident or design has ever produced any thing of the chemical laboratory?
>
> New Orleans Academy of Sciences, *Minutes*

Another set of experiments was performed with Dr. Duncan Macgibbon, on the muscular fibers of the hearts of persons dead from yellow fever, investigating these histologically and microscopically.

One of the annual features of the Medical College of Louisiana and its successor, the University of Louisiana, was a very elaborate and well planned introductory lecture given by each member of the faculty. Sometimes these were on subjects unrelated to any particular course. One of Riddell's most popular was that given November 16, 1852, "The chemistry, physics and vitality of organic cells." This was published by request in the *New Orleans Medical and Surgical Journal.*

At the Cleveland meeting of the American Association for the Advancement of Science, in 1853, Riddell presented four papers, one on the histology of red blood, one on the origin of capillary blood vessels, one on the theory of molecular forces, and one on the structure of *Oscillaria aureliana.* There is some question whether the third was actually read before the assembled delegates, or presented, as we express it, by title. The paper was published in the *New Orleans Medical and Surgical Journal* with the caption that it was presented at the Cleveland meeting. In his paper on histology of blood Riddell gave illustrations from microscopic examinations of alligator blood, human blood, frog blood and *Amphiuma* blood, with sketches. These were carefully prepared and show much detail. The paper on the origin of capillary blood vessels discusses the subject in terms of the development of the ova of the tree frog. The paper on *Oscillaria aureliana* was not published in the *Proceedings* of the American Association for the Advancement of Science.

At a meeting of the Physico-Medical Society, September 14, 1850, Dr. Erasmus D. Fenner read a paper on lead poisoning, contending that lead was present in soda water. Riddell, Dr. James Jones and Dr. A. F. Axson were appointed by the Society to investigate Fenner's claim. The committee disagreed with Dr. Fenner, but were of the general opinion that all water passing through lead pipes contained a detectable quantity of lead. These findings were published as "Report of a committee of the Physico-Medical Society of New Orleans on lead poisoning," in the *Transactions of the American Medical Association.* A similar paper, dealing with "Fatal poisoning from sugar plums" appeared in the *New Orleans Monthly Medical Register.*

On another occasion Riddell spoke prophetically about the virtues of saline springs.

"The Creator has wisely adapted our bodies to those very conditions which are most commonly found throughout the world we inhabit. None of these conditions is more constant than the presence of saline matters in all waters that are employed for drink; and their absence or great deficiency is a common cause of disease. A case in point is the great prevalence of goiter in districts where pure snow water is the only kind used. It is most remarkable that many of the mineral impregnations of water are in quantities which almost defy detection by chemical tests; while at the same time this infinitessimal division of them, afforded by water alone, is the most effectual way of introducing them."

New Orleans Academy of Sciences, *Minutes*

Riddell was consulted in the preparation of the remains of Judah Touro, prominent New Orleans philanthropist, for removal to New England for burial. Riddell was asked to prepare the proper preservatives.

> "He . . . advised that the body be surrounded with charcoal with the additional intermixture of acetate of lead and sulfate of iron. He was happy to say that the result proved perfectly satisfactory."
>
> New Orleans Academy of Sciences, *Minutes*

From the medical viewpoint Riddell's views on capillarity were definitely wrong. He proposed:

> ". . . I suppose in accordance with my own theory of muscular motion, that the nervous influence (electricity) has the power to invite blood (arterial) . . . perhaps no blood can pass through the capillary system which does not undergo a change. I do not suppose the tension or pressure of blood in cases of congestion is not greater than usual. But that the circulation is more rapid because it is permitted to pass into the veins."
>
> *Repository,* vol. 7

Riddell sought to explain animal secretions by means of his permeation hypothesis, which provoked Dr. T. V. Morrow at Worthington. Morrow believed that the brain was compressible, and that

> "the brain moved up and down with the systole and diastole of the heart."
>
> *Personal Journal,* vol. 8

Riddell's point of view was that the brain was

> "perfectly saturated with liquid,"
>
> *Personal Journal,* vol. 8

and therefore incompressible, and devised an experiment with a chicken brain to demonstrate his point. The experiment justified his hypothesis.

Another hypothesis was that apoplexy was due

> "to a congestion and rupture of the blood vessels of the encephalon rather than a compression of the brain."
>
> *Personal Journal,* vol. 8

In some places in his notes he supported the incompressibility of the brain, but in others he permitted the brain some freedom of motion. He attempted to explain the uses of the ventricles and sinuses of the brain by allowing some motion to that organ. He tried to design an experiment to note the movement of the brain during mental stimulation. He was convinced that respiration, the heart and muscular contractions communicated motion to the brain.

Miasm and Contagion-Animalculae-Infectious Diseases

During the Worthington period (1833) Riddell noted his reasons for believing that contagious or infectious diseases were caused by some sort of animalculae. He wrote:

> "I draw a negative argument from the chemical action of inorganic agents. I take this broad position—that when a body acts by virtue of chemical affinity that body becomes expended, in proportion as the action advances. Hence the extent of the effect produced is entirely dependent on the quantity of the agent. Now if contagious effluvia were poisons of an ordinary character, an inappreciably small amount could not produce an indeterminately great effect; while the effluvia seems rather to gather strength from their morbific action, than to become expended like bodies under the controul of chemical affinity.
>
> "Analysis shows us that when the atmosphere is apparently replete with morbific poison that the chemical composition of the air does not vary sensibly from the usual standard: that if there be some subtile pestilential gas or vapour present its quantity must be exceedingly small, wherefore admitting its presence and reasoning on the atomic theory, we could not anticipate any considerable effect.
>
> "But the action and unlimited propagation of contagious matter agree well with the laws of animal nature.
>
> "A law seems to pervade and controul animal nature, as well as the vegetable kingdom, recondite indeed in its nature, but not the less

obvious in its effects. I refer to the degeneration of races. One race or variety will flourish for a time and prevail, but at length it degenerates and is succeeded by another race or variety which has its day and yields its peace in turn. The Indians are disappearing from the forests of North America, and the whites are increasing and occupying the lands. The mammoths, plesosauri, lycadeae, etc. of ancient times are now unknown. This year the maples and buckeyes were infested to an incredible extent by the larvae of a small yellow miller. A year or two hence these insects will probably be almost unknown while some other species of insect may infest the same or other trees.

"No thinking mind can fail to observe an almost perfect analogy between the prevalence and succession of epidemic diseases, and the succession and prevalences of the races adverted to. Animals indeed are infested after this manner by insects visible to the naked eye.

"I cannot but believe that many morbid alterations of structure in the same animals frame bear about the same relation to animals in general—that many species of fungi do to the more perfect subjects of the vegetable kingdom. I allude to warts, cancers, ringworms, wens, perhaps, tubercles, sarcomatous tumours, hydatids, etc."

"It seems to me that the component elements of the animal machine are combined and retained in an unnatural condition by the living principle, or to speak more correctly, in a condition which dead matter has power neither to assume nor retain, it seems to me, I say, that a certain degree of health and energy of the living principle is essential in order that it keep the particles of dead matter over which it is destined to rule, in subjection. That when the living principle does not possess the requisite degree of health and energy then the system is in a condition to favour these fungous growths—in a condition more obnoxious to the depredations of animalculae."

Repository, vol. 4

These thoughts were embodied in Riddell's thesis: "Memoir on the nature of miasm and contagion," which was read before the Cincinnati Medical Society, February 3, 1836, and printed in the same year in the *Western Journal of the Medical and Physical Sciences.* The paper attracted wide attention, and was reprinted in the *United States Medical and Surgical Journal,* and reviewed in the *New Orleans Medical and Surgical Journal.* In essence Riddell advocated that contagious or infectious diseases were caused by

"organized and living corpuscles of various kinds,"

Western Journal of Medicine and Physical Science, 1835, vol. 9, pp. 401-412

that is, he proposed that contagious diseases were caused by bacteria.

Perhaps the clearest presentation of the topic was given by Riddell at a meeting of the New Orleans Academy of Sciences on October 10, 1853, when Riddell attacked a paper by Dr. Isaac L. Crawcour on the cause of epidemics. Riddell stated:

". . . the cause of epidemics is an organic one. He was not prepared to say that it was either vegetable or animal, that it was not of a kind totally different from either. In illustration of such possible existences he alluded to that remarkable class of organisms revealed by the microscope, the Diatomaceae, which are invested with a silicious covering, and which seem to be intermediate between animals and vegetables, partaking of the nature of both. The "period of incubation" which, as is well known, is a characteristic of epidemics, as it is of the evolving of insect life, or the germinating of seeds . . . would seem to be conclusive against the hypothesis of either mineral or meterological causes, which act at once."

New Orleans Academy of Sciences, *Minutes*

At an earlier date, in a lecture to his students at the University of Louisiana, November 18, 1851:

". . . in the microscopic world beings are often met . . . which seem either or both animals and plants . . . as to the relations of animals and plants among each other it can safely be said that they prey upon each other to the full extent of their power."

New Orleans Medical and Surgical Journal, 1852, vol. 8, p. 468

As noted in DeBow's *Commercial Review* (1850):

"Dr. Riddell of New Orleans recently found the monads from boiled peas, just as active as if they had not been subjected to high heat—has found the cholera insect alive, in water condensed from the breath of a cholera patient in collapse—has subjected the monads from human blood globules, to four hours immersion in caustic potash—and still they lived and danced; and I have seen through his wonderful Spencer lens, the same (apparently) monadic animalculae in paints, reduced in distilled water, sporting about the particles of pigment, as if they had not been imprisoned,

probably in the resin, since the paint was manufactured."

Commercial Review, 1850, vol. 9, p. 158

In another experiment

"Sediment from smallpox water (kept hermetically sealed) consists of numerous irregular partly filamentous ragged masses."

Personal Journal, vol. 14

Riddell confirmed his belief in the germ or bacteria theory in these words:

"That miasms and contagion . . . might be minute germs of vital organisms had been vaguely suggested by various writers at various times. Linnaeus entertained that opinion. It was hinted at by the ancients. But the controlling reasons which give confirmation to such an opinion I have never seen adduced by any writer prior to the publication of my memoir."

New Orleans Academy of Sciences, *Minutes*

The memoir referred to, obviously, is his thesis on miasm and contagion (1836).

With the development of his binocular microscope and the many subsequent observations on animalculae, bacteria, body fluids, etc. Riddell was more than ever convinced of the correctness of his theory. In a lecture February 28, 1859, before the New Orleans Academy of Sciences, he described many bacteria, particularly

"one most active little worm, about 1/4000 of an inch long, by 1/40,000 of an inch in thickness along the middle, with both ends alike rounded and enlarged to 1/25,000 of an inch in diameter,

New Orleans Medical and Surgical Journal, 1859, vol. 16, p. 359

which was, he reasoned,

"connected in some way with cholera,"

New Orleans Medical and Surgical Journal, 1959, vol. 16, p. 359

and

". . . rather plants than animals."

New Orleans Medical and Surgical Journal, 1859, vol. 16, p. 359

These microscopic examinations gave ample proof of the organic nature of disease, although Riddell did not clearly identify the bacteria as such. The cholera and tuberculosis bacilli are clearly shown in some of Riddell's drawings. Other materials examined microscopically included blood — human, frog, *Amphiuma;* "moving monads"; vegetable cells; frogs; "ova found on the surface of a puddle of rain water;" capillary vessels, and various protozoans and algae. These observations, made in the 1850's, were with his Spencer instrument, for which he had paid $120, rather than his binocular instrument.

In his Volume 18 of the *Personal Journal* Riddell mentioned that he had borrowed Dr. Edward Hall Barton's lecture notes on miasm, had copied the main points, and inserted comments of his own. These substantiate his early ideas on the nature of miasm and contagion. Barton's statements were shown by Riddell to be capable of interpretation on the basis of the organic theory of miasm and contagion, as well as on Barton's preferred basis of meteorological and external events. Barton's points were:

1. "Miasm is produced and propagated by a temperature not less than 40 degrees nor more than 100 degrees in putrifiable material.
2. "It is evaporated or suspended by heat during the day and falls in the cool of the evening or night.
3. "Miasmata are said to be most abundant in stagnant marshes, ponds, etc.
4. "Winds protect from the influence of malaria.
5. "A covering, as a house, shed, trees, mosquito bars, etc. protect from the influence of malaria.
6. "Flannel is known to be a great protection against the influence of miasm in sticky climates.
7. "Great protection is supposed to be rendered by a grove of trees, a high wall or other such impediment, intervening between a marsh and a house or town.
8. "Elevated positions over or near swamps are often sickly and sometimes eminently so.
9. "The effects of malaria are arrested by frost."

Personal Journal, vol. 18

Riddell noted that the range of temperature specified in (1) was the most favorable to organic life, and agreed with (2) because the

"miasmatic corpuscles . . . became entangled in the dew which is deposited."

Personal Journal, vol. 18

In reply to (3) he noted that mosquitoes, gnats and other insects, infusoria and algae are most abundant in stagnant areas. In reply

to (4):

> "Miasm is thus distributed and attenuated by the winds. Besides I conceive the deposition of dew to be greatly and perhaps essentially instrumental in bringing miasm to act on the system. Now in windy weather dew is very seldom deposited."
>
> *Personal Journal,* vol. 18

In reply to (9):

> "So are the effects of mosquitoes, gnats, ants, etc. Living and organic nature is dormant below the freezing point of water. Some animals and plants, it is true, maintain for themselves a higher temperature than the cold medium around them, and are consequently more or less active. But a vast majority of organic beings die upon the approach of a northern winter, leaving merely dormant germ, ova or sporules to continue the future existence of their respective races. How well this proposition harmonizes with the organic theory of miasm. How irreconcileable with any other! As to vicissitudes of weather do we not have them in winter? Yet certain kinds of miasmatic diseases never originate in winter."
>
> *Personal Journal,* vol. 18

The Riddell-Barton controversy erupted again in 1854 following a paper of Barton's on the cause of epidemics. Barton believed that epidemics were caused by a

> "poison, generated and diffused (conveyed) through the atmosphere."
>
> New Orleans Academy of Sciences, *Minutes*

Riddell wanted to know more about the poison.

> "It must be organic, he indicated, not sure whether it is animal or vegetable. Must be due to some form of organism."
>
> New Orleans Academy of Sciences, *Minutes*

Barton agreed that organisms were probably involved, but also stressed the dependency of climate on epidemics. Riddell

> "could not grasp how heat and moisture alone could account for epidemics,"
>
> New Orleans Academy of Sciences, *Minutes*

and stated flatly that

> "two distinct epidemics can never coexist in the same community."
>
> New Orleans Academy of Sciences, *Minutes*

XVII. THE POST OFFICE AT NEW ORLEANS – 1860-1863

Perhaps the most colorful portion of Riddell's life was the last five years. He was appointed Postmaster of the City of New Orleans by President James Buchanan, August 1, 1860, and took office on August 16, succeeding S. M. Marks. Riddell served during the troubled months preceding the Civil War, during the War prior to the occupancy of the city by the Northern troops, and also during the occupation until February 19, 1863. His tenure in office was the result of unusual circumstances. When the Confederate authorities took over the postal system June 1, 1861, J. M. Reed was appointed Postmaster of New Orleans. He was not confirmed. Then Lionel Berthe was appointed and confirmed, but did not take office. Hence Riddell was in office when the city was occupied by the Northern troops, and remained during part of the occupation under Major General Benjamin Franklin Butler.

Riddell's initial appointment as Postmaster was unusual, even though he was active in Democratic circles, because of his previous difficulties while at the Mint in the 1840's. He was responsible, nevertheless, for a curious chapter in the history of the New Orleans Post Office.

In May, 1861, Riddell wrote to Montgomery Blair, Postmaster-General, asking what he should do in case of war. Blair replied on May 18, indicating that he should take steps to preserve the funds and property of the United States Government, but gave no specific directions.

Following the declaration of hostilities Riddell announced to the citizens of New Orleans that it would be advisable to dispose of any quantities of United States stamps which they might have on hand, since they would be of no value during the Confederate administration. On June 1, 1861, the postal system of the Confederate States went into operation. New postal rates were announced, and arrangements made for the transmittal of mail to and through the United States, and to foreign countries. Riddell was advised by the Confederate Postmaster-General, John A. Reagan, that some arrangements must be made for prepayment of postage until regular stamps were available. Riddell, always full of initiative, made arrangements with John V. Childs, an engraver and printer,

on June 6, 1861, to prepare a series of stamps, now known as the New Orleans Postmaster Provisionals. This was reported in the local press as follows:

> "STAMPS FOR THE NEW ORLEANS POST OFFICE: Our energetic Postmaster, Dr. J. L. Riddell, has made arrangements with Mr. John V. Childs, the engraver, No. 10 Camp Street, for the engraving of five cent stamps to be used exclusively for the mailing of letters at the New Orleans Post Office, and intended principally for the convenience of our citizens, under our new postal arrangements.

Figure 13. Riddell's two cent Postmaster's Provisional Stamp (courtesy of a New Orleans collector).

> "The stamps are very neatly and handsomely engraved, and will be ready for distribution by the end of the week.
>
> "In mailing letters over 500 miles distance, within the Confederate States, the postage will be ten cents for single letters, and 2 stamps must be affixed. In mailing letters for any foreign State, either in or out of the United States, the United States postage stamps heretofore used must be added.
>
> "We learn that ten cent stamps will shortly be adopted. This will prove a great facility and convenience to our citizens, and Postmaster Riddell deserves the thanks of the community for his enterprise."
>
> *The Daily Picayune,* New Orleans, Louisiana, June 6, 1861

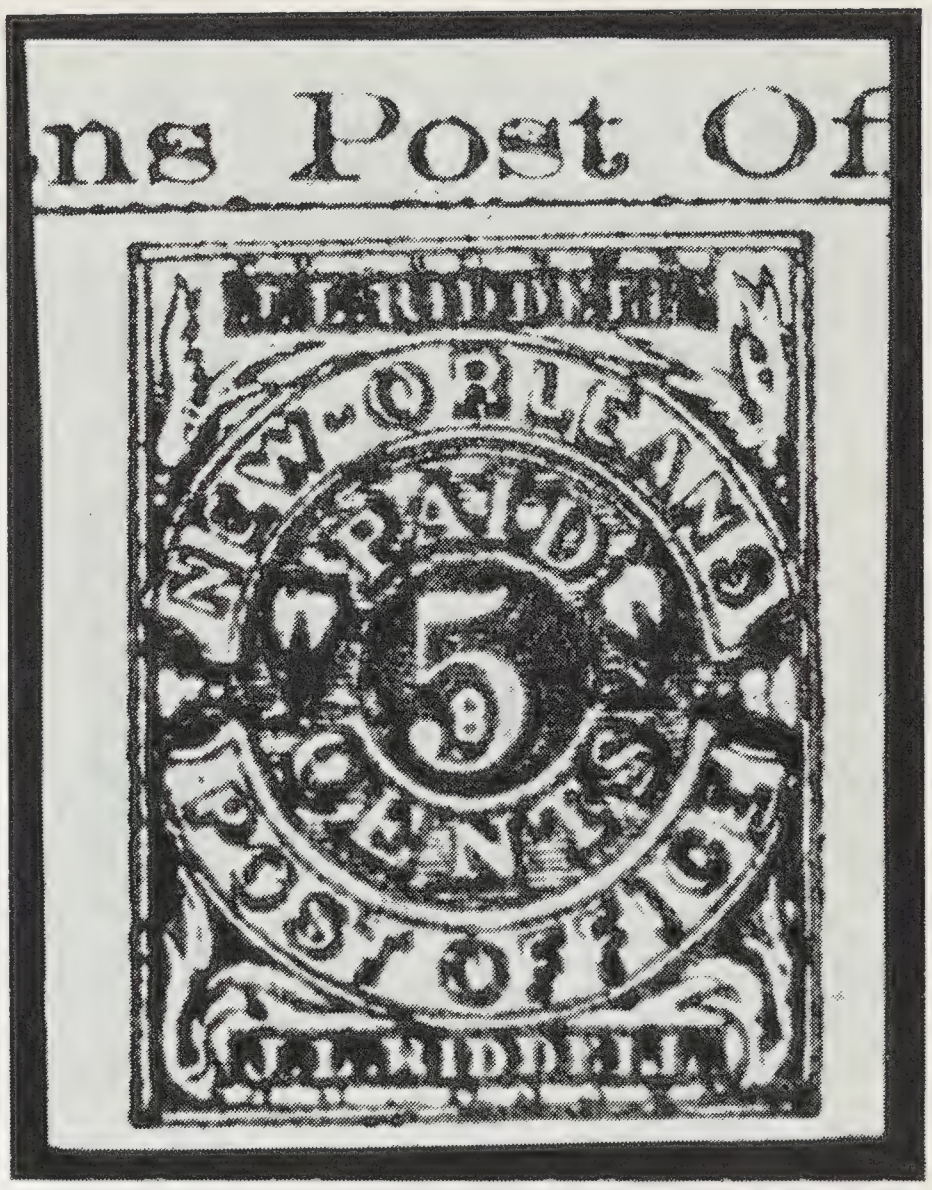


Figure 14. Riddell's five cent Postmaster's Provisional Stamp with part imprint at top (courtesy of a New Orleans collector).

In addition to the postage stamps Riddell ordered a series of stamp checks or paper currency, in denominations from one cent to five dollars, for making proper change on the purchase of stamps. The first stamp was a 5¢ brown, with Riddell's name across top and bottom, and was sold at the New Orleans Post Office beginning June 12, 1861. The impressions were made from a wood cut, and appeared in sheets of forty. The second stamp was a 2¢ blue in a slightly different design. Later, the 2¢ stamp appeared in red. A 10¢ stamp, although mentioned above, was never issued. Eight different basic types

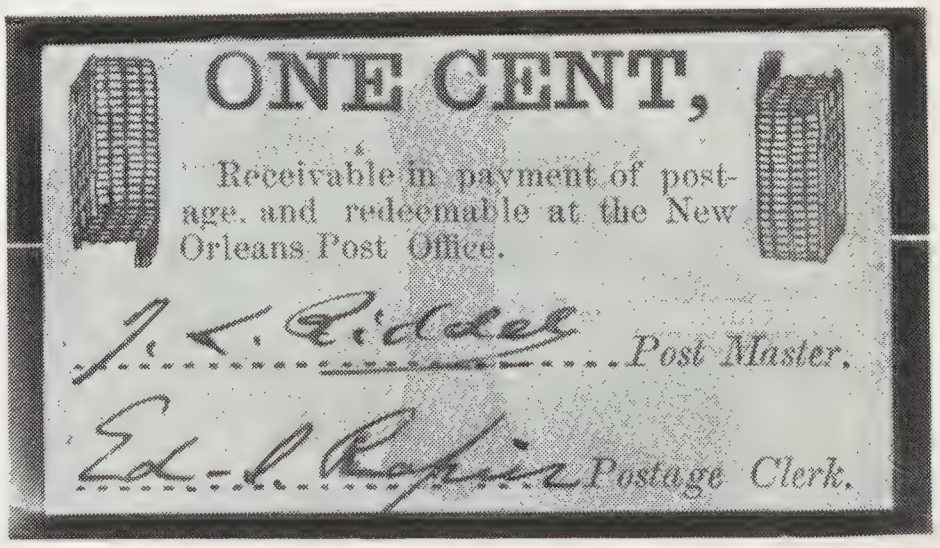


Figure 15. Riddell's "stamp money", one cent denomination (courtesy of a New Orleans collector).

are recognized by philatelic authorities today. Printings were on different grades of paper of white, bluish and yellowish shades. The figure "5" on each stamp contains a small figure "8" within the curve of the "5". The inscribed figures are not all alike, and the significance of this is not known. The new stamps met with the immediate approval of the citizens.

> "All foreign letters mailed at New Orleans for foreign countries have, up to this date, been sent to Washington, and our Post Master thinks they will be forwarded to their destination. He is of the opinion that the Lincoln Government will not stop foreign mails and he has determined to send letters forward to Washington.
>
> "The five cents stamp issued by Post Master Riddell, are now ready for delivery; yesterday five hundred dollars' worth were sold. The plate from which the impressions are made cost only forty-one dollars. Dr. Riddell has written to the Department at Richmond, to have the Post Master General approve of these stamps, when he will issue ten cents and two cents stamps. They have already proved a great convenience to our people and saves great loss of time in making change."
>
> *The Daily Picayune,* New Orleans, Louisiana, June 13, 1861

There was one slight difficulty. Postmasters outside of New Orleans did not accept the stamps and indicated that Riddell was guilty of illegal practice when issuing them. The *Caddo Gazette* of Shreveport, Louisiana, called the stamps

> "bogus stamps . . . They are perfectly worthless, and we advise persons not to purchase them."
>
> Huber and Wagner, *The Great Mail,* p. 145

Riddell was forced to state publicly that the stamps were intended for use in New Orleans, and nowhere else. He added to each sheet of stamps an imprint, top and bottom,

> "Usable exclusively in the New Orleans Post Office."

Even though the regular Confederate States stamp issues were available in New Orleans in 1861, the provisionals were used throughout that year, and until the fall of the city, April 25, 1862, and its subsequent occupation.

Philatelists have detected some forgeries of these stamps, and also certain irregularities in the plates themselves. In addition to the adhesive stamps Riddell issued provisional hand-stamped envelopes, in 2¢, 5¢ and 10¢ denominations, with the stamping made from brass hand stamps. There are two types, one containing simply

PD. CTS.
N.O.P.O.

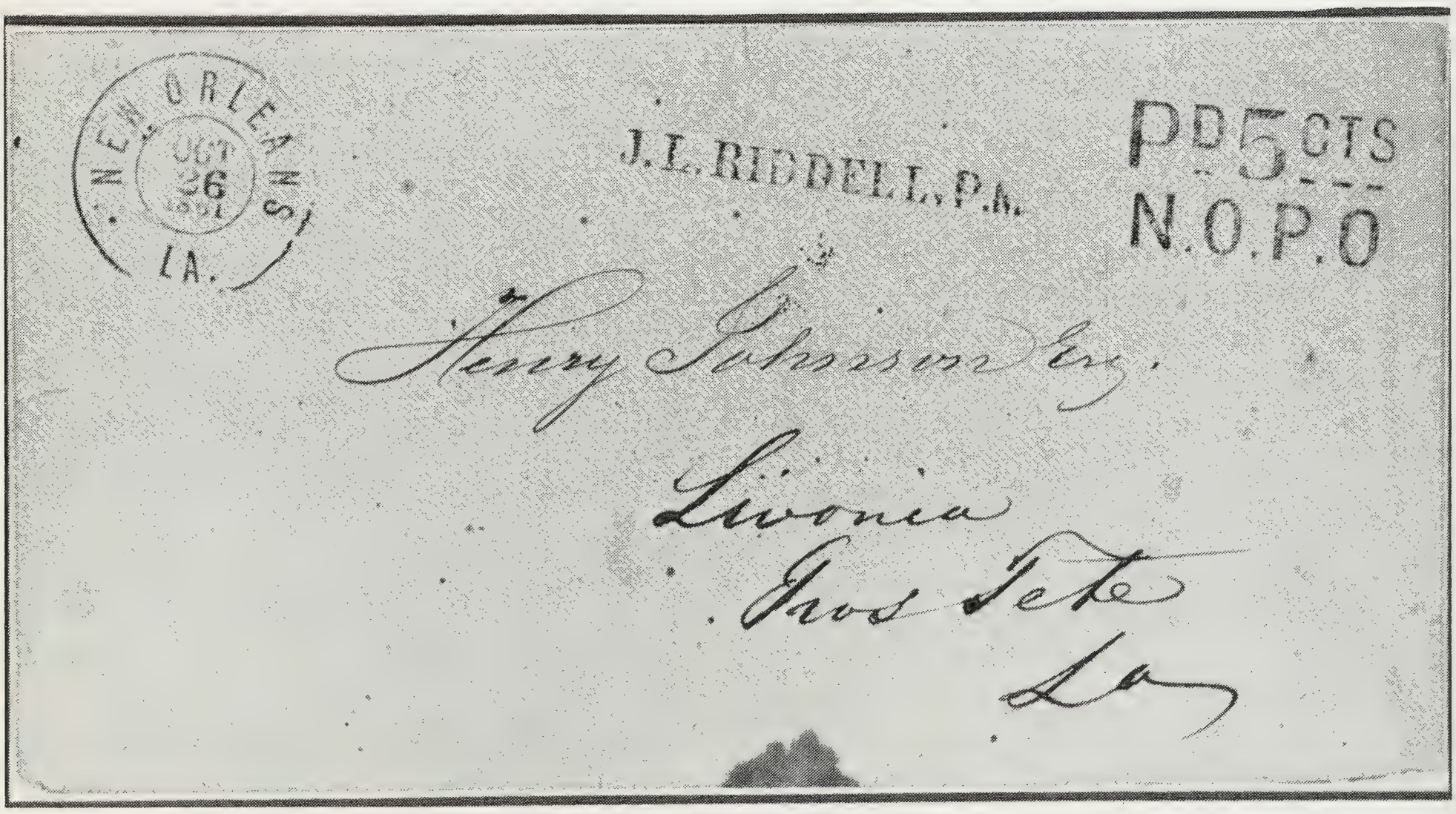


Figure 16. Riddell's handstamped five cent Postmaster's Provisional Envelope (courtesy of a New Orleans collector).

with the appropriate numeral inserted; the other adding

J.L.RIDDELL, P.M.

Riddell also mapped out a blockade-evading route via Texas and Mexico, with the firm of Antonio Costa, a well known commission merchant of New Orleans, for messages and mail.

There is a story that Riddell

> "secreted a number of United States stamps by plastering them into the wall of a building in the old French Quarter in New Orleans, near the site of the post office at that time."
>
> A. E. Waller, *Ohio State Archives and Historical Quarterly,* 1945, vol. 54, pp. 331-360

It is said that he sent the serial numbers of these sheets to the Postmaster-General in Washington. This was regarded as a "treasonable act" against the Confederacy by some of the New Orleans citizenry. Consequently Riddell had occasion to fear for his life. Whether or not this is true, we do not know. The serial numbers nor any correspondence from Riddell on this matter are not now in the Archives of the Post Office Department.

The *Daily Delta* of New Orleans, March 18, 1862, carries the following "Correspondence":

CORRESPONDENCE

New Orleans Post Office, March 12, 1862

To Messrs. J. P. Labouisse
M. Garcia
J. Nicholson
Rich Esterbrook
Thomas Murray

Gentlemen — I have the honor to acknowledge receipt this day of the following procesverbae of proceedings and resolutions, presented to me in this office by yourselfs personally:

(Copy)

CASE OF DR. J. L. RIDDELL

Resolved that a report be made to the association in the case of J.L. Riddell, recommending that a committee of the association be appointed to wait upon him and demand, in the name of the association:

1st. That he immediately resign his office of Postmaster, and forward same to the Postmaster General, in the presence of the committee.

2nd. That he cause an advertisement to be inserted in the public newspapers that he is willing to receive, from all persons indebted to him personally, for rents and otherwise the currency of the Confederate States at par.

3rd. That said committee be further instructed to inform Dr. J. L. Riddell that, in case of his refusal to comply with said requisitions, he will be considered an enemy of the Southern Confederacy, and dealt with accordingly.

J.P. Labouisse
M. Garcia
J. Nicholson
Rich Esterbrook
Thomas Murray
Committee

Ever since the suspension of specie payments by the banks, even to the present time, I have incurred a great deal of undeserved blame, by demanding and collecting specie in certain cases of postal and postoffice dues, and it has been ten thousand times asserted, and many time printed, that I was thus wantonly bringing discredit upon the Confederate treasure notes. But I defy the most searching investigation to show an instance where I was not acting in precise accordance with the laws of the Confederacy and in accordance with instructions from the Postmaster General. Quite lately I have been apprised that there has been got up in this city against me, a great excitement and terrible prejudice, because it was alleged that I refused to receive treasury notes in payment of a private debt, thus aiding to depreciate said note. The fact is that, excepting debts in one case, I never have refused to receive treasury notes for rents, notes, sales of property, etc., and I have no objection to notify the community, that from the lights of me, I shall continue to receive them. The solitary exception is the case of Dr. J.S. Knapp, which has been the cause of excitement and prejudice just before alluded to. In this case, as can be seen by reading Dr. Knapp's letter below, there is really no feature that can properly be construed into disparagement of treasury notes:

(Copy)

Dr. J.L. Riddell:
Dear Sir: I regret to learn that money transactions between us have been the occasion of great blame imputed to you by some of the community. I admit that early in February I had more then Confederate money enough to pay my note held by you and falling due early in March. You asked me for it in exchange for my note, and on which occasion I asked you to continue to hold the note for another year, to which you agreed. Subsequently, receiving more money that I expected I was desirous of paying it, and offered to pay. You replied that expecting to continue my note, you had already, at some trouble, raised money to

meet your own maturing obligations. You never intimated to me that you would demand coin from me, but in lieu you promised to receive the Confederate notes when your taxes became due.

I had no wish to make our transaction public, or in anyway to cause you to be blamed. My object in making the notarial tender was merely to stop the interest, which the notary informed me would be the effect of the legal tender.

Very respectfully yours,
Jas. S. Knapp — 15 Baronne St.

I reply to you, gentlemen, because I think that every communication respectfully worded and signed by any of my fellow-citizen, of the standing which you hold in the community, demands respectful answer. But I cannot acknowledge the authority or right of any person or persons, not clothed with some legal mantle, to inquire into and pass judgment upon my private affairs or my official conduct. Still less can I acquience in an unfriendly judgement passed upon me in secret by a self constituted tribunal, without opportunity of hearing the indictment or being heard in my own defense.

In your first resolution, you demand that I shall immediately, and in your presence, resign the Postmastership. I assure you, gentlemen, under existing circumstances, I have no wish or desire to hold the office. Whenever it pleases the Government to relieve me, I shall relinquish it to a successor duly appointed and qualified. Until then, if life be spared, I have given bonds and sworn faithfully to perform the duties of the office. Make your complaints and substantiate your charges if you have any, before the Postmaster General, and you will be heard and heeded. For me to voluntarily or otherwise abandon the office now, would result in great public inconvenience, and perhaps great losses. To resign forthwith, under the threat of otherwise "being considered an enemy of the Southern Confederacy, and dealt with accordingly," might give color of possibility that I was really so, which I totaly and solomnly deny, and challenge the production of proof. You say your society numbers thousands of men; doubtless strong in organization and potent and prompt to carry out your purposes. I am but one man and my life may pay the forfeit of the position I now take, but I owe it to myself and to those who bear my name and must inherit my character, to do no single act which could cause them to blush for their sire.

Respectfully, your obedient servant,
J. L. Riddell, Postmaster

The Great Mail, a history of the New Orleans Post Office, by Leonard V. Huber and Clarence A. Wagner, carries a paragraph about Admiral David Glasgow Farragut's expedition to take formal possession of the Custom House, where the Post Office was located, April 29, 1862:

> ". . . The two officers in command entered the Custom House where they were met by Dr. Riddell, who received them cordially and remarked,
>
> "Thank God that you are here. I have been a Union man all the time. I was appointed by Buchanan and not by Jeff Davis: he only allowed me to remain."
>
> "Riddell then showed the little group to the roof of the building and was present when the Stars and Stripes was again hoisted over New Orleans."
>
> Huber and Wagner,
> *The Great Mail,* p. 150

On May 3, 1862 Riddell wrote to General Benjamin F. Butler:

> "I desire you to send me to the above address a pass to enter the Post Office, that I may finish hunting over the debris left by the late mob, for the vouchers, etc. I also desire to arrange my accounts and remove some little private property belonging to me, one item of which is three hundred pounds of bacon, now needed by my family.
>
> "I was appointed Post Master of New Orleans in Aug. 1860 by President Buchanan. I found myself in charge of the office of the office when the Confederates took possession, June 1st, 1861. They shortly afterwards appointed J.M.Reed, Postmaster, who was not confirmed. After six weeks they appointed and confirmed Lionel Berthe as New Orleans Postmaster but he failed to take possession of the office. I have never formally resigned the U.S. appointment. I have sent my last account to the Post Office at Washington on the 27th. day of Aug. 1861. If I remember right, the Department gave me great credit for a satisfactory settlement, I having paid drafts for the Department in final liquidation as late as the middle of Aug. amounting to nearly $150,000 after the seizure of the mint on Jan. 1861.
>
> "I received in answer to my inquiries from Postmaster Gen. Blair minute instructions dated May 18th, 1861 as to the proper course for me to pursue under the anomalous circumstances that existed or likely to occur, which instructions I followed.
>
> "As a matter of course, I fell under the suspicion of individuals and secret societies and it

has taxed my powers of watchfulness and prudence to preserve my life from the mob to this time, although I have resided here for 26 years.

"At the present time I consider my life in danger. Under all the circumstances I feel assured in advance that you will grant me the pass and permission which I request.

"I have kept so far in safety some twelve or fourteen thousand dollars worth of U.S. postage stamps and stamped envelopes and I would ask you if practicable to point out some opportunity for their return to the Post Office Department, Washington City, as they are all of the old, and, as I understand, repudiated pattern and therefore useless, except as vouchers or perhaps you may think preferable to have them enumerated and destroyed by a commission of your own appointing."

Huber and Wagner,
The Great Mail, p. 150

In Burton J. Hendrick's *Statesmen of the Lost Cause,* the following paragraph concerning Riddell appears:

"Pickett carried the precious packet in person to Dr. Riddle, Postmaster of New Orleans. He explained to that functionary the nature of the contents, enjoining the utmost care and secrecy in forwarding the documents to Richmond. Dr. Riddle, greatly impressed, promised that he would give his personal attention to ensure safe transmission. This promise was carried out only too faithfully. For this Dr. Riddle was a spy in the employ of the Federal Government. Instead of sending the documents to the State Department in Richmond, he forwarded them to Mr. Seward in Washington."

B. J. Hendrick, *Statesmen of the Lost Cause,* p. 137

Whether or not Riddell could be considered "a spy in the employ of the Federal Government" is open to question. We have no real evidence to substantiate this charge. Riddell was definitely a Union sympathizer, but was considered a conscientious and able worker in the Post Office until the occupation of New Orleans.

One telegram in the National Archives, on a blank of the Washington and New Orleans Telegraph Line, is of interest. There is no year indicated. Whether or not this pertains to the pre-Civil War period, or the actual Confederate period, is open to dispute. No accompanying papers bear any relation to the message.

"The following communication was received at Washington 20th 11 o'clock 0 min.p.m. dated New Orleans 20th 9 o'clock 20 min.p.m. for Hon. Jeff. Davis.

"Professor J.L.Riddell competent and responsible, will accept our mint treasuryship. Please telegraph me where it is too late to forward recommendations."

Geo. Dunlap
Message in National Archives,
Fiscal Section

If this means that Riddell was prepared to accept the mint treasuryship with the Confederate authorities, it is quite surprising, in view of Riddell's Union sympathies.

Riddell's successor as Postmaster of New Orleans took office February 19, 1863, John M. G. Parker. He had served as acting postmaster under appointment by Major General Benjamin F. Butler from May 2, 1862, until the regular Federal appointment was made.

XVIII. POLITICS – 1863-1865

The role played by Riddell during the latter part of the Civil War is not too clear. In spite of his position in the New Orleans Post Office, Riddell was an outspoken opponent of secession. Following the capture of New Orleans and during the military governorships of Generals Benjamin Franklin Butler and Nathaniel Prentiss Banks, he was a vocal Union sympathizer. He was associated with the Conservative Unionists, and with the Constitutional Union Party of Louisiana. This group was agitating as early as October, 1863, for a general election for Louisiana.

Riddell and his associates petitioned President Abraham Lincoln for permission to hold the regular election in Louisiana on November 2, 1863. In Riddell's own words,

"In 1863 I earnestly cooperated with a large number of conservative Union men with the object of loyalizing the entire states of Louisiana, Texas, Arkansas and Mississippi, and bringing them fairly and squarely into their old places in the Union . . . In June a deputation from the planters of Louisiana asked Mr. Lincoln to instruct the Military Governor of Louisiana to permit the recurring biennial election to be held November 2, 1863, under the State Laws. Mr. Lincoln declined to do so just then."

New Orleans *Times,*
October 21, 1864

Riddell and members of the Louisiana Congressional Delegation also visited President Lincoln, urging his cooperation, but their efforts failed because, as Riddell phrased it,

> "the abolitionists took over Congress."

In spite of Lincoln's refusal the group persisted and made plans to hold the election. Opposition elements also planned to have tickets in the election.

A group known as the Executive Central Committee of Louisiana, led by W. W. Pugh, E. Ames, and John Quincy Adams Fellows, met in New Orleans on October 26, 1863, and issued a proclamation to the citizens of Louisiana, urging them to vote in elections which would be held on November 2, 1863. The New Orleans *Times* came out editorially against the proposal, indicating that General Nathaniel P. Banks, Butler's successor, had not been consulted.

General Banks was indeed opposed. General George P. Shepley, then military governor, was also opposed and proceeded to prohibit the statewide election. The United States Treasury appointee in New Orleans, a Mr. Dennison, wrote:

> "Governor Shepley, by two or three firm but mild letters put a stop to the whole proceeding . . . the whole movement . . . was nothing but copperheadism and secessionism in disguise . . . and resolved itself into a ridiculous farce."
>
> Chase Correspondence, vol. 2, p. 423
> From W.M. Caskey, *Secession and Restoration of Louisiana,* 1938

However an election of sorts was held in certain parishes of the state. A quotation from the New York *Herald* appeared in the New Orleans *Times* for December 18, 1863:

> "We are reliably informed that an election was regularly held in Louisiana on the first Monday in November as the State laws directed, and that Mr. J. L. Riddell of New Orleans was elected Governor of the State, and Messrs. A. P. Field of New Orleans, Joshua Baker of St. Mary's Parish, and Thomas Cottman of Ascension Parish were elected representatives to Congress. . ."
>
> New Orleans *Times,* December 18, 1863

This was the first report of the results of the pseudo-election reaching New Orleans, and evoked much unfavorable comment in the press.

Field and Cottman presented themselves in Washington to be seated in Congress, with credentials signed by Riddell. The New Orleans *Times,* December 23, 1863, reports the proceedings under the heading

> "The Great Louisiana Farce — Certificate of 'I, John Leonard Riddell, Governor of the State of Louisiana.'"

The *Times* continued:

> "The Congressional *Daily Globe* . . . gives us fuller accounts than have yet been published here, of the broad and extraordinary farce which the so-called "Governor" and "Representatives" of Louisiana are just now acting in Washington, with unbounded applause from all quarters."

Quoting from the *Daily Globe,* December 8, 1863, the credentials referred to are as follows:

> "I, John Leonard Riddell, governor of the State of Louisiana, duly and legally elected by the voters of said state, in pursuance of the Constitution and laws of said state, do hereby certify that at an election begun and held in said State on the 2nd day of November, 1863, in accordance with the laws of said State, for the purpose of electing five representatives from said State to the 38th Congress of the United States the following named persons were regularly elected to represent said State in said Congress for the term of two years from the 4th of March, 1864, namely:
>
> From the 1st Congressional District—A. P. Field
>
> From the 2nd Congressional District—Thomas Cottman
>
> From the 5th Congressional District, comprised of the whole State of Louisiana, Joshua Baker.
>
> "All of whom were regularly elected in accordance with the Constitution and laws of said State of Louisiana.
>
> "In testimony whereof, I, John Leonard Riddell, Governor, elected as aforesaid and duly sworn, do hereby commission said persons so elected as aforesaid and duly sworn, to represent said State in the 38th Congress of the United States and do hereby give these credentials in evidence of their loyal and regular election as aforesaid: and I do hereby affix my name and private seal of office (the public seal thereof being forcibly kept in the possession of the public enemies of the State) on this 20th day of November in the year of our Lord 1863 and the 88th year

of the Independence of the United States of America."

John Leonard Riddell
Governor of the State of Louisiana

New Orleans *Times,*
December 23, 1863

In the discussion which followed the reading of this document in the House of Representatives, Representative Stevens of Pennsylvania referred to Riddell as a

"man whom nobody in the United States ever heard of as governor."

After much discussion the credentials of Field and Cottman were referred to a Committee, and at a later date they were refused their seats.

The New Orleans *Times* ridiculed Riddell, and hinted that he had not

"taken the oath in the President's last proclamation."

This refers to the loyalty oath.

In 1864, Riddell served as president of the Union Association, organized with the approval of the military. In a speech delivered before the "Democratic and Conservative Mass Meeting" held in New Orleans, October 13, 1864, Riddell reviewed the early War years:

"In critical times or great emergencies requiring a course of action to be wisely decided upon, it often appears that there is advantage to be gained from simply keeping cool, and carefully thinking over the matter a second time. These were critical times for the South; but the South, especially South Carolina, did not keep cool, did not think the matter over a second time. The reckless politicians and place holders in the South madly rushed into rebellion and open warfare. They induced and ultimately forced the people to go with them; although in several of the states, Louisiana for instance, it is certain that a large majority of planters and citizens, entitled to vote, were disposed to loyalty, union and peace. In this instance it is said the thing was arranged by a fraudulent appeal to the ballot box and that the detailed result of the voting was never published.

"Mr. Lincoln had been legally and duly elected President of the United States; Mr. Lincoln should have been accepted as such by all the States and all the people. In my humble opinion—fearlessly and publicly and frequently expressed then, while the propriety of secession was being discussed, and continuously held until now—the South were insane not to accept him and try him. I remember there was some such prejudice against Mr. Fillmore but he made as excellent president. Who can say that Mr. Lincoln having attained the summit of his ambition would not have given satisfaction even to the South, if we had contrived to keep our delegations in Congress and given him a peaceable chance?"

New Orleans *Times,*
October 21, 1864

The thoughts expressed by Riddell were, to say the least, unpopular.

Riddell was considered a leader of the "conservative" group of Unionists and led that delegation to the Chicago convention of the Democratic Party in 1864. The delegation, which was not seated, asked to be "united with the Northern democracy." The group was definitely anti-Lincoln and pro-McClellan in the 1864 presidential race, using the slogan "McClellan and Moderation."

Another paragraph from the October 13, 1864, speech, which was published in its entirety by the New Orleans *Times,* reads:

"I find no fault with the professed basis on which the United States government prosecuted the first year's war — the preservation of the Union and Constitution and the enforcement of the laws . . . I rather think the large confederate armies will be conquered and dispersed by the Union forces; but this result will not bring lasting peace, or accustomed prosperity to the Southern country."

New Orleans, *Times,*
Oct. 21, 1864

In a state still divided between Union and Confederate forces, where the local citizenry had relatives and friends in the Confederate armies, such remarks did not endear Riddell to the community. If the tone of all of his discussions and remarks since 1861 were of that sort, it is a miracle that some hot-headed citizen did not eliminate him from the local scene.

Newspaper comment on Riddell's speech was favorable. The *Times* noted:

"Governor Riddell was next introduced and he made a most amusing speech."

New Orleans, *Times,*
October 14, 1864

The *Daily Picayune* reported:

"John Leonard Riddell, Esq. was then introduced and kept his audience in a roar of

> laughter at his wit and dry hits at the administration party."
>
> New Orleans *Daily Picyaune,*
> October 14, 1864

However Riddell's prestige further diminished when Lincoln was re-elected.

About this time there was evidence of failing health. In the Riddell obituary we note

> "... he had experienced slight attacks of paralytic affection, which were monitory to himself, his family and his friends, of the danger he was in of ultimate more serious and most probably, final fatal ones. This led him to be generally careful to avoid decidedly exciting causes, but, perhaps, neither so constantly nor so particularly as he might. He still pursued his scientific inquiries, still scrupulously attended to his multitudinous private business affairs, still took an active share in public matters, still occasionally filled public offices, still mingled with the world, and partook of its pleasures, though not given to excesses."
>
> *The Daily Southern Star,*
> New Orleans, Louisiana, October 8, 1865

At the close of hostilities Riddell was one of the citizens receiving presidential pardons. In the archives of the Howard-Tilton Memorial Library, Tulane University, there is a photostat of his pardon, reading, in part:

> "Full pardon and amnesty from President Andrew Johnson for all offences by him committed arising from participation direct or implied in the said Rebellion. . ."

It is dated August 14, 1865. The proclamation indicated that Riddell must take the oath prescribed, as stated in the presidential order of May 29, 1865. The pardon was announced in the *Tagliche Deutsche Zeitung* of New Orleans on November 12, 1865. Whether or not Riddell knew of the pardon before his death on October 7, 1865, is not known.

Dr. Riddell was the presiding officer at the Louisiana State Democratic Convention, held at the Mechanics Hall, New Orleans, October 2, 1865. After a brief word of welcome, Riddell gave what turned out to be a sensational speech, in which he stated:

> "Whatever may have been thought of the policy of secession, all are now prepared to admit that the secession of Louisiana was worse than a crime — it was a blunder.
>
> "The principal cause of the war was the negro. Certain members of the radical faction are trying to foist him on us as a citizen. The negro has never reached the status of the Caucasian . . . I am not willing to meet him as an equal, socially, or at the ballot-box."
>
> New Orleans *Daily Picayune,*
> October 3, 1865

At the evening session of the Convention Riddell "was allowed to explain his position." A member of the Convention presented a resolution to the effect that Riddell's remarks

> "attempted to rekindle the antagonisms of a former period by characterizing the acts of the State of Louisiana as criminal and treasonable, thereby presuming to cast a stigma and a censure upon many if not all the members of this Convention. . ."
>
> New Orleans *Daily Picayune,*
> October 3, 1865

The resolution proclaimed that the Convention was not responsible for Riddell's remarks. When Riddell promised to explain his position in the public press the resolution was withdrawn. Riddell's speech had offended the citizens, to say the least, and

> "touched a sensitive chord in the moral and political structure of the assembly and it was consequently assailed as false in morality, and, as far as politics were concerned, as ill timed and indiscreet."
>
> New Orleans *Times,*
> October 8, 1865

Another article quoted Riddell:

> ". .,. (he) felt sure that all of those present now recognized the act of secession as a crime involving as it had, bloodshed and treason."
>
> New Orleans *Times,*
> October 3, 1865

He was assailed by the audience, and stopped by protests and boos on that memorable October 2, 1865.

> "It need not be disguised that notwithstanding the position in which Dr. Riddell stood before the Convention as the Chairman of the National Democratic State Executive Committee, and in that capacity calling the Convention to order, his political antecedents and his political relations with a large portion of the Convention were not such as accorded with a very strong feeling which prevailed. Nor can there be much doubt that this was the real source from which sprang a very severe attack upon him for making use of the

very common phrase above referred to. The harshness and plausibility of the attack upon him for this, affected him very much, especially when he found that even his explanation, that he intended nothing like what the phrase had been construed to mean, was not received as sufficient to satisfy those who had taken offence in it."

The Daily Southern Star,
New Orleans, October 8, 1865

Riddell indicated that he would prepare an explanation, and went to the office of the *Daily Southern Star* to write it.

"We saw nothing of him till late in the evening, after this occurrence, but we are informed that he had in the meantime continued much excited. About 8 o'clock in the evening he went home, but finding that a note had been left at his house by a gentleman connected with this office, he came hither to inquire what that gentleman desired to see him about. He spoke to one of the gentlemen in the editorial room, apparently quite calm, and in his usual health — free, in fact, from excitement of any kind. He was introduced into the private room of the proprietor (Edwin L. Jewell), and after a brief conversation with that gentleman, in which he manifested the same collectedness, he commenced writing an explanatory card upon the subject of his misinterpreted remark. While he was doing this, the editor having business to attend to, Dr. Riddell was left alone in the office; presently the noise of a heavy rattling fall was heard, but attracted no attention, as it was supposed to be that of some heavy material about the office, and it was not for some two or three minutes afterwards that the editor, passing the door of the office, saw, to his alarm, that Dr. Riddell had fallen to the ground and lay extended on his back apparently dying. He immediately called for assistance, which was on the spot, and such as the case allowed of was promptly given. In the course of half an hour Dr. Riddell had sufficiently revived to warrant his being put into a chair, although he could not sit there without support.

"He had been seized with an attack of apoplexy, attended, as is frequently the case, with partial paralysis. He could not be understood, although he endeavored to answer every question put to him; but his mind was wandering, incoherent, and deranged. He gradually improved so far that his removal to his residence was judged proper, and he got there shortly after 10 o'clock. There he continued to improve to the extent of apparently overcoming the muscular paralysis, and spoke clearly and in cases rationally and to the point, although up to the time he was left in the hands of his family physician, his mind was so unsettled that he was not aware he was at home, and knew nothing of having been at this office. We have heard it stated that he was out the following day, but think there is some misapprehension on this point. At all events, he subsequently relapzed, and although the first medical aid in the city was afforded him — Dr. Stone being called in consultation — he gradually sank till he departed this life, as we have stated.

"On examining the paper on which Dr. Riddell had commenced writing, in the office of the editor of this paper, it was found to contain nothing but unintelligible incoherencies and repetitions. . ."

The Daily *Southern Star,*
New Orleans, Louisiana,
October 8, 1865

Riddell's death occurred at 8:20 a.m. on October 7, 1865.

The obituary notice in the *Daily Southern Star,* as given above, was the most elaborate and detailed account of his last hours. Other obituaries were shorter and more general. The obituary in the New Orleans *Times* reflected the bitterness of the citizens, but acknowledged that

"his intellect was searching, analytic and vigorous, and his scientific attainments were of a very high order . . . Indeed he had a passion for scientific inquiry, and his liberality in that regard was in marked contrast with his ordinary economic habits.

"In chemistry he was especially well versed, and as professor of that science in the University of Louisiana he was regarded as a shining light. His labors and researches in microscopic observations and descriptions, in the various fields of the literature and science, have been highly appreciated both in Europe and America."

New Orleans *Times*,
October 8, 1865

The New Orleans *Daily Picayune* commented editorially on Riddell's death. The editor considered Riddell's convention remarks inoffensive, and, after a brief biographical sketch, concluded:

"A man of large brain, of great industry, patience and equanimity, he acquired a vast fund of scientific knowledge, and what is more remarkable, combining with these qualities great tact, thrift and management in the practical affairs of life, he accumulated a large fortune. . ."

New Orleans *Daily Picayune,*
October 8, 1865

Another account, written by Dr. John T. Scott for the *New Orleans Medical and Surgical Journal,* noted that Riddell had given evidence

> "that the silver cord was loosening, and the golden bowl about to be broken. . ."
>
> *New Orleans Medical and Surgical Journal,* 1866, vol. 19, pp. 284-287

indicating that his mind was definitely failing at the time of his death. His true condition is not known, but evidence establishes that he was greatly agitated about political subjects. Dr. Scott cites Riddell as a practical benefactor of mankind, and notes his many acts of kindness and philanthropy, and his strong vitality.

Rufus Waples and Dr. James S. Knapp prepared the customary obituary notice and resolutions for the New Orleans Academy of Sciences. This includes a very meager sketch of his life, and the following paragraphs:

> "As a lecturer on Chemistry in the University of Louisiana he was remarkable for perspicuity of style and diction. He enjoyed the highest esteem of the students among whom he was extremely popular. Unlike many men of learning, his attainments formed no barrier to a personal approach by the unlettered; nor did they prevent him from kindly and constantly aiding others, nor from giving that attention to business affairs in which he was eminently successful and by which he accumulated and left to his family a large and productive property.
>
> "In the New Orleans Academy of Sciences of which he was one of the founders, he acted most efficiently as President nearly all of the time from its formation. Among the varied subjects under discussion his uncommonly retentive memory, his accurate and general information and his happy faculty for imparting knowledge enabled him to cast light on almost any subject under consideration. Their thanks are especially due to him for the preservation of the domicile of the Academy from pillage and waste during the perilous times of Civil War."
>
> *New Orleans Academy of Sciences* November, 1865

The New Orleans Academy of Sciences then adopted formal resolutions, which were published in the *Daily Picayune* on November 10, 1865:

> "There was a meeting of the Academy of Sciences on Monday evening at which the principal business done was the receiving and adopting of the report and resolutions of a committee on the death of Dr. Riddell, formerly president of the Academy.
>
> "Resolved: 1. That in the death of Dr. Riddell every department of the natural and exact sciences has suffered loss; for he excelled in each and won an enviable reputation both in Europe and America, for his varied scientific attainments, and his highly valuable contribution to the useful arts.
>
> 2. That we, his fellows, not only bear testimony to his wonderful mental endowments, his analytical powers and his unusually retentive memory, but also to his goodness of heart, his urbanity of manners, his placidity of temper and his admirable qualities in all the relations of life.
>
> 3. That as a society we lament in him the loss of a father who, ever devoted to the advancement of science cooperated with such men as Hale, Barton and Benedict in founding this Academy. Its President nearly ever since its foundation, his zeal, industry and eminent attainments have contributed very much to make and sustain its character among the learned bodies of the civilized world.
>
> 4. That we tender to his bereaved widow and children and to our fellow members Dr. S. S. Riddell his son, and to Prof. W. P. Riddell, his brother, our heartfelt sympathy and condolence, feeling that our intimate relations with the deceased enable us, in some degree, to appreciate the deeper grief which Heaven has visited upon them.
>
> 5. That we will wear the usual badge of mourning for thirty days.
>
> 6. That a copy of these resolutions be presented to the family of the deceased and that the foregoing outline of his life be published, with these resolutions, in such newspapers of the city as will give them insertion."
>
> Respectfully submitted,
> Rufus Waples
> Jas. K. Knapp
> Committee
>
> J. S. Copes
> vice-president

Funeral services were held from Dr. Riddell's home, #12 Dryades Street, on October 8, 1865. Burial was in the Riddell family tomb in the Protestant (Girod Street) Cemetery. The tomb here referred to is a different one than mentioned earlier. At some time during the 1850's Riddell had constructed a large granite tomb, and in it were buried Dr. Josiah Hale and Riddell's son Gaen Leonard. In this tomb were eventually

Figure 17. Riddell's original tomb in the Protestant (Girod Street) Cemetery, New Orleans, Louisiana (photograph by the author).

Figure 18. Riddell's final resting place, Metairie Cemetery, New Orleans, Louisiana (photograph by the author).

placed his widow, Mrs. Angelica Brown Riddell, and Mary Riddell Hogsett, and Lephe Riddell Woodward. Prior to the demolition of the Protestant Cemetery the contents of this tomb were removed to a plot in the Metairie Cemetery. There is an appropriate granite headstone, with the names of Riddell, his wife and daughters.

At the time of his death Riddell was a man of considerable wealth. There was extensive litigation concerning his succession, with the son Dr. Sanford Schrager Riddell demanding his proper share. Since Riddell died without making a will and since the seven surviving children by the last marriage were minors, tutors and guardians were appointed. Careful inventories were prepared and kept of all receipts and disbursements, even to the smallest item. The total value of the estate was $152,916.53, which included real estate appraised at $120,000. According to the Louisiana Civil Code, 2359th Article, in effect at that time,

> "... the said Mistress Angelica E. Riddell is entitled to receive in the said succession only a child's share in usufruct, and has therefore to receive in usufruct only 1/9 of the whole property of the said succession..."
>
> Notarial Archive #38026
> New Orleans, Louisiana

Apparently Sanford and the rest of the family did not agree, for he pressed his case for partition of the estate and division of the property. He won his case in court.

Peter and Susan (then Mrs. A. P. House) also appealed the succession March 24, 1879, after Peter had come of age.

In the 1867 inventory there are thirteen lots of property in Orleans Parish, Louisiana, listed, as well as mention of holdings in Jefferson Parish, Louisiana. Riddell was also the holder of notes amounting to $17,533.34. A Sheriff's Sale, conducted by Harry T. Hays, Sheriff, of notes, stocks, due bills, coins, scrips of insurance, etc. was held on May 11, 1867, as part of the action to settle the estate.

— — — — —

John Leonard Riddell — scientist, educator, politican, business man and devoted family man — a New England Yankee transformed into a New Orleanian — will be remembered as an innovator and leader in his field by the historians of science.

XIX APPENDIX:

The Riddell Mint Correspondence

The following letters are part of the United States National Archives, Washington, D.C. in the General Records of the Department of the Treasury, Record Group 56, and in the Records of the Bureau of the Mint, Record Group 104. The letters have been placed in a reasonable order, and have retained the original spelling, phraseology and punctuation as far as possible to determine from the originals and from microfilm. There are a few obvious errors in grammar and spelling, but these have not been corrected.

Letter #1

R. M. Patterson, Director of the United States Mint, to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. May 28, 1840.

Dear Sir,

I received letters yesterday from Peter I. Levick and Ewald Ernst, complaining of the circumstances under which they had been discharged from your Mint, and the latter making accusations of a very grave character, against Dr. Riddell. The same accusations had come to my ear before, indirectly, through a correspondent of one of our workmen, but I felt assured that it must be without foundation, as I had just received a letter from you that was utterly incompatible with the existence of any such offence as that averred. The accusation, as you know, is that Dr. Riddell has employed a hand or hands at certain wages to be paid by the government, but with a private bargain that a part of the wages was to be given up — the first story said for the private gain of Dr. Riddell, the second for the benefit of a Dr. McCarthy, employed in the establishment. The inference which I draw from Ernst's letter is that he had made the accusation in question — that you enquired into it and found it false — and that you immediately dismissed him as a slanderer. You will excuse me, however, for asking you for the exact truth in this matter, inasmuch as the affair has been already forced upon my attention.

It is proper to state that the letter of Mr. Levick is perfectly respectful to Dr. Riddell, against whom he makes no accusation or complaint; except that he dismissed him without cause. Levick has respectable connections here, and says that he writes only for the purpose of removing the unfavorable impressions which his discharge might

make against his character.

Very respectfully,
Your faithful servant,
R. M. Patterson

Letter #2

R. M. Patterson, Director of the United States Mint, to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. June 13, 1840.

Sir,

From editorial notices in the N.O. Sun of the 30th and 31st ult. and other such sources I am pained to hear of evil reports and suspicions, and investigations, regarding the Melter and Refiner of your Mint. I pray you to let me hear from yourself — the only legitimate source to which I can look for information — the truth as to a matter in which I have so deep an official interest.

Very respectfully,
Your faithful friend,
R. M. Patterson

P.S. In connection with this subject it may be proper to mention that I received, a few days ago, a letter from Dr. John McCarthy, who, it seems, was employed in Dr. Riddell's department, and who makes a bitter attack upon that officer. As it appeared however, that McCarthy was himself under suspicion and was greatly irritated by this circumstance, and as you must necessarily have been acquainted with the whole affair, I did not think my interference in the case called for.

Letter #3

John Leonard Riddell to Hon. Levi Woodbury, Secretary of the Treasury, June 13, 1840.

Sir,

That injustice may not be done to myself I feel it incumbent on me to address you at this time.

For some weeks past no gold has been coined in this mint. The last three melts of gold ingots have been cracked in the coining department in rolling: — and yet by proper annealing I found no difficulty myself in rolling successfully samples from each melt. Knowing and being now able to establish that the ingots have all been of good quality, I have made a written request through our Superintendent, to be permitted to use for an hour the annealing furnace and gold rollers in the coining department, that I may so far prepare the gold for ingots of the next melt, by partial rolling before delivery to the coiner, as to preclude the possibility of their being cracked in subsequent operations, pledging myself to send you my resignation, if I fail in rolling the ingots well. The coiner declines my request.

The matter in its commencement was submitted to Dr. Patterson, whose reply we wait, and whose decision, I hope will remove all difficulties.

I should have been loath to trouble you thus, were I not well assured that secret efforts are being made to prejudice my standing with the Government. The inclosed certificate with the remarks preceding it, cut from one of our city papers, will give you an idea of some of the groundless measures taken against me. Conscious that I have well and faithfully performed my duties, I have but this single request to make: — that if complaints seemingly worthy of your attention, be proffered against me, I may not be condemned unheard, nor without due inquiry. Pardon me for adding that my time for twelve years past has been almost exclusively devoted to chemistry and the natural sciences. In 1836 I was employed to make a geological reconnoissance of Ohio. For a while I held a professorship in the Cincinnati Medical College, and for four years past have been professor of Chemistry in the Medical College of Louisiana. For my standing and ability I can, among many, call the following men to vouch: My old preceptor, Prof. Amos Eaton, Troy, New York; Prof. B. Silliman, New Haven; Prof. John Torrey, New York; Prof. J. B. Rogers and Prof. Aiken, Baltimore; Dr. S. G. Morton, Philadelphia; Dr. S. P. Hildreth, Marietta, Ohio; Dr. Daniel Drake and Prof. C. W. Short, Louisville, Ky. with most of whom I now maintain a correspondence.

Very respectfully,
Your obedient servant
J. L. Riddell
Melter & Refiner

Notation in pencil, not too legible, apparently by Secretary Woodbury. Definitely not Riddell's handwriting.

Actg. supt — Before its arrival — The agts in the complaints made against you had ordered a statement of the complaints against you transmitted for your explanation. They are as follows:

. . . offer to you to inquire is denied . . . a copy of your letter will be sent this day to the Director and his immediate attention invited to the subject.

LW

Write accordingly to the director giving him . . . called on Doct R for explanation of the charges.

LW

R387, June 24
NOrleans

Printed statement, from a New Orleans newspaper, attached:

Communicated

Two editorial communications have appeared in the Sun, casting suspicions on the integrity of the melter and refiner in the mint, and promising that an investigation about to be instituted, will soon be made known. The higher officers in the mint have never entertained or express the least doubt of the integrity of the melter and refiner, and the only

investigation proposed was volunteered by himself, to silence the false reports raised by the misrepresentations of an individual who was lately in his employ as a laborer. Here is a copy of the Treasurer's report:

Treasurer's Office, United States Branch Mint
New Orleans, May 31, 1840

Be it known, that I have this day, at the request of Dr. J. L. Riddell, smelter and refiner of this mint (and in the presence of J. M. Kennedy, Esq. Superintendent) examined the contents of his vaults; I have weighed the bullion as far as it is susceptible of being weighed, and have estimated the balance, and am satisfied that the amount of gold and silver bullion in the possession of Dr. Riddell, is fully equal to that called for by the books of my office.

H. C. Cammack
Treasurer, U.S. Branch Mint

Letter #4

R. M. Patterson, Director of the United States Mint, to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. June 46, 1840.

Sir,

I have received New Orleans papers today, of the 1st and 2nd inst., sent, I presume, from your Mint, and containing Mr. Cammack's certificates regarding Dr. Riddell's account as Melter and Refiner. This is well. But I am also informed, indirectly, through the correspondence of a gentleman not connected with the Mint, of an outrage subsequently committed, and in which Dr. Riddell and one of your workman — Nixon — were parties. The story, as related, is that one of Dr. Riddell's men — McCarthy — having taken offense at his principal, had made complaints which gave rise to the investigation into Dr. Riddell's affairs; and, that, in revenge for this conduct, Dr. Riddell, accompanied by his brother and Nixon, armed with clubs, and daggers or Bowie knives, had gone to McCarthy's chamber, and beaten him severely. The end of the story is that Dr. Riddell, and his brother, and Mr. Nixon, had been turned over to the Criminal Court for this assault, and that the operations of the Mint were suspended.

I hope that this shocking report is not true, or at least that it is exaggerated. It can hardly be possible that I should not have your representations of the matter, before this letter reaches you; but, in any event, I am most anxious to hear the truth, and to hear it from you. It is a case that deeply concerns you, for it involves the reputation of an institution under your immediate charge. The practice of a resort to brute force in support of private character must be considered by all moralists as equally wicked and absurd; what terms then can be used, when the same resort is made for the support of public character, and is applied to a subaltern? I know not code can justify it.

Very respectfully,
Your faithful servant,
R. M. Patterson
Director

Letter #5

Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana to R. M. Patterson, Director of the United States Mint, Philadelphia, Pennsylvania. June 6, 1840.

Sir,

I have received from Mr. Cammack, a note, a copy of which I now enclose, together with the letter for you, mentioned therein. In my last of the 2'd inst, accompanying our statement for May, I observed that I would in a short time communicate to you the cause why no gold had been coined for some time at this Mint, and other information in relation to our affiars.

With regard to gold coinage, the matter stands as stated by Mr. Commack. "Several melts have been made of gold, which have been returned uncoined," the ingots having, on every occasion proved too brittle. But there is a difference of opinion between the Melter and Coiner, concerning the cause of that brittleness, each contending that it originates in the Department of the other. Dr. Riddell is persuaded that his ingots are good. He says that they are annealed by Mr. Tyler at too high a temperature, (all that is required being "a dull red heat,") and that being then immersed in the pickle, and suddenly cooled, they are consequently brittle.

The Coiner, on the contrary, maintains that they are not well toughened, and that they should be so made by the Melter, as not to be affected in the cooling by any heat that is not beyond the "cherry red," which he says is several degrees higher than that insisted upon by the Melter.

I am myself unable to determine between them, and am convinced that you are the only person to whom I can appeal, that would (in coming to a decision yourself, or in furnishing me with such information as would enable me to do so), give satisfaction to both parties. I could send you an ingot selected indiscriminately by me, from the number returned to the Melter as unfit to be coined, whereby you could settle the question very soon.

An occurrence has recently taken place between Dr. Riddell, and a person of the name of McCarthy, who was employed in his department; which I think it my duty to lay before you, as it may before its consequences are over, interfere with our operations.

McCarthy had a quarrel a few days ago with Dr. R. and left the Mint. A report, of which he was the author, that the Melter was a dishonest man, and would prove himself a defaulter if called upon to settle his accounts, soon reached the ears of his securities. They applied to me for information, and desired that I would suggest what course they should pursue. I advised them to call on Dr. Riddell, to communicate to him what they had heard,

and to state that in justice to himself as well as them, he should, without delay, throw open his vaults to the Treasurer, in order that he might examine whether their contents correspond with the amount with which he was charged. Dr. Riddell made not the slightest objection, and you will find the result in a certificate herewith enclosed, issued by the Treasurer on the day on which the examination was made, and which was inserted in those newspapers in which the report above-mentioned had been previously noticed.

On the day succeeding, Dr. Riddell went to the lodgings of McCarthy and whipped him severely. He was accompanied by his brother, who is the foreman of his department, and a Mr. Nixon, one of his men. He took them with him, he says, merely to prove that he was without any kind of weapon. The three were shortly after brought before an officer of Justice, who, upon hearing the evidence, committed them all for trial before the Criminal Court.

The punishment for assault and battery is fine, or imprisonment, or both at the discretion of the Court. In case of the conviction of either of the workmen, their places may easily be supplied, but what are we to do if the Melter and Refiner should be sentenced to such imprisonment as would materially interrupt the operations of the Mint? I will apprise you immediately of the result of the trial.

I am, sir, very respectfully,
Your obdt. servant,
Jos. M. Kennedy,
Supt.

Copy of Treasurer's Certificate, referred to in J. M. Kennedy's letter to R. M. Patterson.

(From the *New Orleans Sun* of June 2, 1840)

Treasurer's Office,
U.S. Branch Mint
New Orleans, May 31, 1840

Be it known that I have this day, at the request of Dr. J. L. Riddell, Melter and Refiner of this Mint, (and in the presence of J. M. Kennedy, Esq. Superintendent), examined the contents of his vaults; I have weighed the bullion as far as it is susceptible of being weighed, and have estimated the balance, and am satisfied that the amount of gold and silver bullion in the possession of Dr. Riddell, is fully equal to that called for by the books of my office.

H. C. Cammack
Treas. U.S. Br. Mint

Note from H. C. Cammack to R. M. Patterson: June 3, 1840.

Sir,

. . . The silver coinage during the past month was larger than ever before made in one month in this Mint. With a good supply of bullion we could get on more rapidly than I had imagined possible. The Coiner struck on the 30th all 40,500 half-dollars in one press.

In gold we have done nothing for a long time. The same difficulty now arises about gold ingots, that created so much trouble last month about silver ingots. Several melts have been made of gold which have been returned uncoined.

I will here remark to you candidly, and I do it with reluctance, that the Melting and Refining department, in its operations, has not reached the anticipations I had entertained, in consequence of the recommendations so warmly made by the friends of Dr. Riddell — nor has he succeeded in preserving in the Mint, that harmony and good feeling, so much to be desired, and without which the operations of the Mint must be retarded, and the situation of other officers rendered unpleasant. As it was I who first brought Dr. Riddell's name before you, for nomination, which I did without knowing him, and without his knowledge, I deem it incumbent on me to apprize you of my disappointment. . .

I am, with considerations of
respect and esteem,
Your faithful servant,
H. C. Cammack

Note from H. C. Cammack to Joseph M. Kennedy, undated.

My dear Sir,

Enclosed I hand you a letter for Dr. Patterson, and if you think it not objectionable, please to forward it to him.

My remarks about Dr. Riddell are drawn from me only by a sense of justice due, as I believe to Dr. Patterson and to myself. Having the first recommended him for appointment, I conceive that I am obligated to communicate any disappointment which I have met with subsequent to the nomination.

As I am activated only by a sense of duty, I trust that there will be no action on what I have written, and for that reason I suggest to you the propriety of my letter being considered private. I do this with more propriety as you have intimated to me your intention of reporting to Dr. Patterson on this subject.

Believe me, very Sincerely,
Cammack

Letter #6

R. M. Patterson, Director of the United States Mint, to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana, June 18, 1840.

Sir,

I hasten to acknowledge the receipt of your letter of the 6th inst. giving me information, in an authentic form, which my late correspondence will have shown you that I was seeking with great anxiety. I do not hesitate to say that I most heartily disapprove of Dr. Riddell's conduct in the affair of Dr. McCarthy, and I shall deem it my duty to represent it to the government It is for the Presi-

dent to determine what course to take in the case, and it is possible that it may not lead to the removal of the officer in question, but if it should, it will be of the greatest importance that no time should be lost in finding a successor, and I deem it right, therefore, to ask you to tell me, in confidence, if you know of any individual competent to fill the station. A practical acquaintance with the business is not to be expected but an acquaintance with Chemistry is. I should think that any gentleman who has had a good medical education might soon acquire the practical knowledge necessary. Our present Melter and Refiner has had no other ground to build upon, and he became in a short time, a competent and effective officer. I consider it of great importance that all persons to be attached to your Mint should be acclimated to New Orleans, and this must, of course, be looked to, if a new appointment is to be made.

I am assured both by our old and by our present Coiner, that there is no difficulty whatever in the annealing of gold. There is not the same inconvenience from overheating, which occurs in silver. If the gold ingots to which you refer could not be rolled without cracking, the fault must have been in the preparation of the metal by the Melter, and not in the annealing by the Coiner. I should deem it quite unnecessary to send a specimen ingot here; but, if the parties desire it, I do not object to this course.

Very respectfully,
Your faithful servant,
R. M. Patterson,
Director

Letter #7

R. M. Patterson, Director of the United States Mint, to Hon. Levi Woodbury, Secretary of the Treasury, June 19, 1840.

Sir,

I feel it my duty to send you the enclosed copies of a correspondence regarding Dr. J. L. Riddell, the present Melter and Refiner of the Branch Mint at New Orleans. You will see from it that my own information is as yet imperfect, yet it is sufficient to convince me that the choice of Dr. Riddell was an unfortunate one, notwithstanding his character as a scientific man and the strong recommendations in his favor. He has quarrelled with and discharged his workmen, he has lost the regard of his fellow officers and he is giving bad ingots to the Coiner, and does not seem able to make them better. Lastly comes the affair with one of his dismissed hands — McCarthy — which has brought disgrace upon the Mint, and exposed him, and two of his men whom he led with him, to a criminal trial.

You will, I presume, judge it proper to lay this matter before the President.

Very respectfully,
your faithful servant,
R. M. Patterson
Director

Letter #8

R. M. Patterson, Director of the United States Mint, to Hon. Levi Woodbury, Secretary of the Treasury, June 20, 1840.

Sir,

Having sent to you yesterday copies of a correspondence respecting Dr. Riddell of the New Orleans Mint, it may be right to mention that I have just received from him a long letter dated the 8th inst. All of it, however, which has regard to his affair with McCarthy is comprised in the following paragraphs:

> "In conclusion I must allude to a subject rather unpleasant. Contrary to the dictates of my better judgment, but from notions of charity, near the 1st of April I admitted to a laborer's station and pay in my department, Dr. John McCarthy—bred an apothecary in Cork, Ireland, more recently a student in our Medical College. He became greatly dissatisfied because I did not find him worthy of promotion. For a few days he took upon himself to promulgate the most slanderous falsehoods in relation to my official doings. He said he wrote a letter to you on the subject. As the slander or libel mite undergo a legal investigation I have to request that you will transmit to myself, or Mr. Kennedy if you prefer it, the original letter, as a copy will not answer."

I have deemed it proper to add this paragraph to the correspondence sent to you, though it does not perhaps give any additional light upon the case, and is certainly more remarkable for what it suppresses than for what it relates.

Very respectfully,
Your faithful Servant,
R. M. Patterson
Director

Letter #9

R. M. Patterson, Director of the United States Mint, to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. June 27, 1840.

Sir,

I have to acknowledge the receipt of your letter of the 15th inst. explaining the circumstances of Ernst's discharge. It is a satisfaction to find that they correspond exactly with what I had supposed to be the true story, and had so stated in my letter making the inquiry. In fact, I never doubted the propriety of Ernst's dismissal. I have had some doubts as to Levick, but I suppose your promised letter will remove them. Had not his discharge some connection with a desire to make room for Dr. Riddell's brother, and has it not also been the immediate cause of the defect in the gold ingots?

I have received from the Secretary of the Treasury a copy of a letter to him, of the 13th

inst., from Dr. Riddell, on the subject of these gold ingots. It is a most extraordinary thing that a doubt should exist as to the fact whether these ingots are sufficiently ductile for the operations of the coiner. We cannot understand, here, how a dispute can exist over so plain a matter. It may be possible to roll some ingots, and yet they may not be possessed of that degree of ductility which may be fairly required by the coiner. If they are defective, I think it very improbable, as I have already told you, that the defect arises from the annealing; while, on the other hand, it is by no means an easy matter to make ductile alloys of gold. The process followed by us was explained in a communication formerly sent to your mint, and which has I presume come into the hands of Dr. Riddell, but I will give you a general view of it, as my doing so may enable you to form a better judgment as to the merits of this dispute.

You have gold, either fine or of high quality, and which may be perfectly ductile, and you are to bring it down to standard by adding copper. Now it is a general rule that this cannot be done directly, without making a brittle mass. You have, therefore, to prepare an alloy — called toughened gold — made by adding to gold an excess of copper, and then melting it down with successive doses of nitre, so as to remove portions of the copper and other oxidizable metals, and produce a mass which will vary in firmness, but which is best at about 700 to 750. This alloy is hard and rings like bell-metal — the ringing being the test of goodness used at the mint. The toughening is then assayed, and the proper proportion melted down with the fine gold, to make the standard metal required.

Now if Dr. Riddell has simply failed in making ductile standard ingots there ought not, considering his want of experience, to be any great astonishment expressed, or any great blame attached to him. The difficulty could have been removed by greater care, or, if the true process was not known to him, by asking information from this mint. I would not, for a moment, think of impeaching an officer, placed in the circumstances of Dr. Riddell, on such a complaint as this. But, if the ingots are really unfit for the coiner and Dr. Riddell refuses to change them, and insists that the coiner is not competent to judge of them, then he must bear the blame. Surely you can judge of this matter. If, however, you have a difficulty to do so, the best way to settle this point may be to send an ingot to us that has been refused by the Coiner and approved by the Melter.

In my view of Dr. Riddell's case, the worst feature in it is the outrage committed on MacCarthy. I deemed it my duty to present the case to the government, and, in doing so, also mentioned the charges as to the ingots, on which, however, I do not lay great force unless it may be shown that the ingots being bad, he has refused to amend them.

I have no objection to your showing this letter to Dr. Riddell.

Very respectfully,
Your faithful servant,
R. M. Patterson
Director

Letter #10

John Leonard Riddell to President Martin VanBuren, June 18, 1840.

To his Excellency Martin VanBuren,

Sir,

I have been informed that some complaints have been laid before you, having reference to my standing as melter and refiner in this mint — the office you were pleased to confer upon me some eight months since. I hear that great stress is laid upon the circumstances and possible consequences of an assault committed, with the open hand upon a person who had recently been employed in the mint, though at the time, no way connected with it.

What I did, I was advised to do by the officers of the mint, Messrs. Kennedy and Cammack; and by them and others my conduct was afterwards warmly approved. It is true, I have been convicted of an assault and battery, but as a civil action is pending relative to the same matter, no sentence will be given for a year or two, until the latter be first decided. The Judge in the Criminal Court assures me that mitigating testimony relating to the slander and libel which caused the assault will be admitted and that the punishment shall be pecuniary, rather than in the way of imprisonment.

Conscious of having faithfully done my duty, *my brief request is that I be not sacrificed without a fair hearing nor without due inquiry.*

I should be sorry to suffer wrongly in your estimation—*at the instance too of some who are unfriendly to your reelection.*

Respectfully your
most obedient
and humble servant

J. L. Riddell

Notation: File with the complaint — W
(Probably Levi Woodbury).

Letter #11

Hon. Levi Woodbury, Secretary of the Treasury, to John Leonard Riddell. June 24, 1840.

Notation: Branch Mint at New Orleans to which I invite your attention.

Dr. Riddell has been called on by the Department for explanation of the charges in the former communications.

Very respectfully,
L W Secy of Try

Sir,

Before the receipt of your communication dated the 13th inst. the President had directed a statement of the charges made against you to be

transmitted to you for your explanation. They are as follows, viz:

1. That you have unnecessarily quarrelled with and discharged your workmen — that you have lost the regard of your fellow officers and that you have not succeeded in preserving in the Mint the harmony and good feelings so much to be desired and without which the operations of the Mint must be retarded and the situation of the other officers rendered unpleasant.
2. That you have given bad ingots to the Coiner and do not seem able to make them better.
3. That the day after the examination of the contents of your Vault by the Treasurer, you went accompanied by your brother and one of your workmen to the lodging of Mr. McCarthy, formerly one of your workmen, who had left the Mint, and whipped him very severely — that this transaction has brought disgrace upon the establishment and subjected you as well as those who accompanied you, to a criminal prosecution.

Your early attention to such course of explanation and refutation as these complaints seem to require, is desired, and in the meantime a copy of your letter will be sent this day to the Director and his immediate attention invited to the other subject mentioned therein.

Very respectfully,
L. W. Secy of Try

Letter #12

John Leonard Riddell to Hon. Levi Woodbury, Secretary of the Treasury. July 14, 1840.

Sir,

I have the honor to submit for your consideration the following reply to your letter of the 24th of June. I will take up the charges therein contained in the order of their enumeration.

1st. (a) That you have unnecessarily quarrelled with and discharged your workmen — (b) that you have lost the regard of your fellow officers, (c) and that you have not succeeded in preserving in the mint the harmony and good feeling so much to be desired, and without which the operations of the mint must be retarded and the situation of the other officers rendered unpleasant.

To begin then,

(a) *That you have unnecessarily quarrelled with and discharged your workmen.*

To this charge I shall plead not guilty. It is true, that for good reasons, which I have set down in writing, and am prepared to establish, I have had occasion since holding the office of melter and refiner, to discharge two or three of my workmen; but with none of those discharged have I ever had any altercation of the least semblance to a quarrel. I prepared a detailed statement of the circumstances attending their dismissal with a view of transmitting it to you; but the accompanying letter of the Superintendent (marked K) since received, will I conceive, meet and obviate that charge satisfactorily. In reference to this, the letter of Mr. Bertrand, who speaks from continued opportunities of personal observation, may also be consulted (vide U). MacCarthy, the only one with whom I had even any verbal altercation, left the mint of his own accord. He, from his own confession, had been inveigled into a plot to do me injury, for which he had been promised advancement in the intended reorganisation of the mint.

(b). *That you have lost the regard of your fellow officers.*

Permit me with deference to remark, that whoever may have been the author of this charge, it would have been more tangible, by averring that for alleged reasons I have *deservedly* lost the aforesaid regard. You cannot expect to hold one man accountable for the arbitrary dislikes and caprices of another; especially as some men are so unreasonable as to consider differences of opinion on matters of business, politics or science, as good grounds for personal enmity.

This charge has been pointedly disavowed by all my fellow officers except the coiner. (See the close of the Superintendent's letter, marked I2; and the assayer's letter near the close, marked P)

(c) *That you have not succeeded in preserving in the mint the harmony and good feeling so much to be desired and without which the operations of the mint must be retarded, and the situation of the other officers rendered unpleasant.*

This too, I must take the liberty of saying, I regard as a general and rather indefinite charge. It would seem to imply that it is especially and exclusively my province to preserve "in the mint the harmony and good feeling" for my *own* part I have ever studied to secure peace. I have found no fault — made no criticisms, preferred no charges, interfered with no other department.

When I first came into the mint, a stranger to most of the officers, I soon saw that we had the elements of discord. On my first interview with the coiner I was astonished to hear him with great warmth and earnestness speak disrespectfully of the assayer, both in respect to his official competency and moral character. I made bold to check him, and told him that heretofore I had not found it difficult to maintain friendly relations with gentlemen who might differ between themselves, without taking sides with either; — that I trusted this instance would not prove an exception. That from personal knowledge and observation I had confidence in Dr. Hort as an assayer; and that I had resolved neither to acquaint nor interest myself with the former difficulties in the mint. I was pained afterward to discover, that this really frank and impartial course of mine was misconstrued. I should not mention the foregoing circumstances did I not look upon it as demonstrating that the want of harmony is really owing to an inveterate, long cherished feud, to which I have refused in any way to become a party.

The only disturbance of good feeling and harmony, in which I have been concerned, has arisen from conflicting opinions on the quality of ingots: — my course in reference thereto has been

open, candid, fair and tending to peace, for proof of which I refer to my letters to the Superintendent (Vide A, B, C, D) From this charge I am exculpated likewise by the testimony of Mr. Bertrand and Dr. Hort (Vide P, T, U)

In conclusion then I assert that this charge cannot apply to me.

2nd. *That you are giving bad ingots to the coiner, and do not seem to be able to make them better.*

The charge at this time cannot relate to silver ingots. What I might here say on silver ingots can be gathered by reference to my letters to the Superintendent (A, B, V) and the letters of the weighmaster (T) and assayer (P).

In respect to the rejected gold, I have had no difficulty in rolling successfully samples from every melt; yet when the same has been returned cracked from the coiner, I have never refused to remelt it, and to the best of my skill and ability endeavored if possible to improve its quality. The accompanying sample was rolled from an ingot of the first rejected mass. (Vide X).

The merits of this controversy can be best judged of, by reading the correspondence on the subject between the Superintendent and myself (Vide C, D, E, F, G, H). It will thus be seen that every proposition or appointment, for test, trial or reference, was rejected or receded from. I was most anxious to send an ingot to Philadelphia for trial in the parent mint; but though at last three ingots were taken from melt No. 14 on the 2nd of July, they yet remain in the treasurer's vault.

I am forced to say, though without any feeling of personal enmity on my part, that I have been wholly at a loss, and am so still, to account for the uncompromising course of conduct pursued by the coiner in relation to the gold. That he was not disposed to cooperate or accomodate, cannot but appear in perusing the series of notes which passed between us, the object of which on my part, was to submit a sample of Melt No. 14, to the test of rolling, as I had successfully the preceding rejected melts. (This correspondence is marked Q from No. 1 to 8)

It is really the assayer's province to decide whether ingots are of proper quality for being coined. I will therefore refer you to his letter on the subject (marked P).

The next day after receiving the reply of the Superintendent (H) to my letter of the 26th of June, (G), I gave him fully the explanation of the cause of the coiner's failure in working the gold "dictating" no terms whatever. This explanation you have in the paper marked M. The day subsequent I made the same explanation in presence of the Superintendent, Treasurer and Coiner; and I am rejoiced to hear from the Superintendent, that on Friday 11th inst. the coiner succeeded in working satisfactorily $8000 of the very gold, melt No. 14, about which we have had so much controversy.

Now from the manner in which a melt of gold is made, and without interruption cast, it necessarily follows that whatever is inherent in the physical nature of one of the ingots, must be so in all the ingots of the melt. Therefore if one portion or ingot of the melt can be wrought, all can with equal facility be wrought. Therefore if one quarter eagle has been made from Melt No. 14 the whole of Melt No. 14 might have been wrought into coins.

I trust now, however, that all difficulties in regard to the gold will disappear.

In conclusion then, I think it has been made apparent, that I have *not* been giving bad ingots to the coiner — that if the ingots had been thin, such as he had previously wrought (Vide M near the beginning) this cracking would have been much less likely to take place. But even admitting that I *had* given "bad ingots to the coiner" and did "not seem to be able to make them better" yet considering that I have held this office little more than six months, and never saw the "communication formerly sent to this mint" on the subject of preparing gold ingots (Vide W). I am at a loss to divine on what good grounds this charge has been made against me.

3. *That the day after the examination of the contents of your vault by the Treasurer, you went accompanied by your brother and one of your workmen, to the lodgings of Mr. MacCarthy, formerly one of your workmen, who had left the mint, and whipped him very severely — that this transaction has brought disgrace upon the establishment and subjected you as well as those who accompanied you to a criminal prosecution.*

I have already entered so fully into the circumstances of McCarthy's case, in the accompanying copy of a letter to Dr. Patterson (S) that I have little to add here. It cannot be considered in any other light than as a private personal affair; for McCarthy did not belong to the mint, and the occurrence did not take place in the mint. I had the greatest possible provocation — and the advice of our superintendent and Treasurer and my friends to chastise him severely. I had their warmly expressed approbation afterwards. In the laws of this state to which I am answerable, a penalty is provided adequate to my offence (There is not however, the *remotest probability* of my imprisonment). In respect to disgrace having in consequence been brought upon the establishment, let me refer you to the accompanying letter from Dr. Jones (R vide also U) which expresses very fairly the opinions and sentiments entertained in this community.

Allow me again to suggest, that neither my duty to the government as a public officer, nor the public interest, is in any way implicated in this matter. It can neither affect my skill nor integrity, nor has it affected my standing in community. Unpleasant it is, I admit, but to no one more so than myself.

Here I close my explanations and here I rest my cause. I cannot resist the impression that you will consider the impeachment as having been satisfactorily met.

To me the inquiry now very naturally presents itself, *whence came these charges?* Our superintendent expresses surprise that I should so misconceive his character as even to inquire of him, whether preferred by him; averring that "it is not in his character to make an attack in the dark. Had it ever entered his mind, to prefer any of the charges, to no one would his intention have been communicated sooner than myself." (Vide 12). Who alleges then, that I quarrel with my workmen, that I have lost the regard of my fellow officers, that I disturb the harmony and retard the operations of the mint, and that I from incompetency make bad ingots and that I have brought disgrace on the establishment?

With the exception of the assayer, we are all equally new and inexperienced. The treasurer only had a copy relating to his own department from those full instructions for every department, sent to this mint on its first organization. The instructions for the coiner and melter and refiner, are said to have been sent last summer to the seat of government. These things considered, I have wondered that subjects of controversy did not much more frequently arise. The conversion of crude bullion into coin, is effected by a series of chemical and mechanical operations, delicate and refined, of which very few are well competent to judge. Now the Director of the present mint, not only has had the benefit of long experience, but he is well known for his profound scientific attainments. Had our worthy, though inexperienced Superintendent, possessed but a share of these advantages, the contentions between the coiner and myself, always relating to physical fact, could never have arisen to any serious height. Nevertheless, one success so far, as shown in the amount coined, is comparatively respectable, though much short of the real capabilities of the mint. (For an estimate of what can be done in my department, Vide V)

The office of melter and refiner in this mint was conferred upon me, during my absence from the country, without my knowledge, and of course without my solicitation. I find it involved great responsibility, and requires the incessant devotion of time, besides calling in requisition all the skill and resources derived from long devotion to chemistry. Had I forseen but a tithe of these unpleasant matters, I should have pondered before accepting the office. But now that my credit is assailed I cannot voluntarily come forward and resign it. My grandsires fought in the revolution. I am an American, and feel too sensibly what I owe to my country and to my own good name, to shrink thus tamely from my duty. One chief consideration actuates me at this time: — that as the wise intention of the government in establishing and maintaining this mint, was to subserve the true interests of the *people,* I see that I may be of essential service in assisting to carry out that intention, and thus to resist the strong and subtle efforts, heretofore made and *at this time* making by the banks to get virtual possession of this mint and turn it to their own account.

With great consideration
I remain your
Very humble and
Obedient Servant,
J. L. Riddell
Melter & Refiner

The following documents are attached to this letter, as noted in the body of the letter:

(A). John Leonard Riddell to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, La. April 20, 1840.

Sir,

You are aware there is a conflict of opinion respecting the quality of the silver ingots which I lately delivered to the Treasurer. In order that truth may be arrived at, I would respectfully suggest that hereafter, commencing this day if you see fit, you take, or cause to be taken, by some unconcerned officer or clerk, indiscriminately from each melt one or more ingots, to be separately weighed and marked, and deposited in the Treasurer and Assayer's assay-piece box. That if then any diversity of opinion should arise between the coiner and myself respecting the quality of the ingots, the whole of those reserved should be transmitted to Dr. Patterson for trial in the parent mint.

Respectfully,
Your obt, Svt,
J. L. Riddell

(B). John Leonard Riddell to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. April 23, 1840.

Sir,

In your verbal reply to my note of the 21st inst you mention that the mint could not be out of so large a fund as the trial ingots which I proposed would amount to. I would therefore modify my suggestion to the following: While the ingots are passing through the Treasurer's hand, in being delivered to the coiner, let some concerned person take from each melt a single ingot, at random. From the part of this whence the assay is usually taken, let a piece weighing say three or four ounces be cut, weighed, marked and deposited in the assay-box for coins, and lastly sent on to Philadelphia for trial and criticism in the parent mint.

Or, as you suggested, I would willingly submit the ingots taken as above to any skilful and disinterested chemist or silversmith who may be found in the city.

Respectfully, your obt sert
J L Riddell
M & R

(C). John Leonard Riddell to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. June 9, 1840. Marked "Confidential".

Sir,

I cannot express to you the sorrow that I feel, because the last melt of gold ingots have cracked in rolling.

After the ingot has been rolled to twice or three times its length, it cannot easily be cracked.

In asking the following favor, believe me, I have no other motive but to assist in the conversion of our gold bullion to coin. I would ask through you of the coiner, the use of the gold rollers and annealing furnace for an hour or so to prepare my ingots for delivery, after I make the next melt of gold. I intend to deliver them partly rolled. I feel that my reputation and standing in the mint depend upon it; and so earnest and confident am I in the matter that I am willing to stand or fall by the result.

Truly your
Obedient Sert
J L Riddell

(D). John Leonard Riddell to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. June 18, 1840.

Sir,

The gold ingots Melt No 14 cast on the 16th inst have been approved by the assayer, and are now in my vault. I shall hold myself in readiness in presence of your self and the officers of the mint as you suggested to have their toughness, quality and fitness for coinage tested, at anytime you may designate. If afterwards the parties chiefly interested should entertain different opinions, I would respectfully suggest that you select an ingot from the melt, and permit its being sent to the Philadelphia mint for trial.

Respectfully,
Your obt servt
J L Riddell
M & R

P.S. I have devised a simple mode of filing ingots by machinery. A common small iron turning lathe is the principal item of expense. By this plan I expect a day's work of a man, with a file, can be accomplished in half an hour at most. As there are several lathes in the mint, I would ask you whether I cannot be accomodated, at least with the temporary loan of one to make the experiment. I would also like the steel instrument made by Mr. Pratt, while in my employ, working at the ingot moulds.

J.L.R.

(E). Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana to John Leonard Riddell. June 19, 1840.

Sir,

You will be pleased to make your delivery of the gold ingots mentioned in your note to me of this morning — I am desirous that all our rules and forms for the transaction of business should be strictly adhered to, and consider that any experiment upon these ingots before a regular delivery to the coiner made in his department, would be a departure therefrom — I shall direct him, after he will have tried 8 or 10 of them to make a report to me. If he fail to work them, we can *then* resort to the test of which you speak.

Resp. y'Obt Ser't
J.M. Kennedy
Supt

P.S.
I find that the "several lathes in the mint" mentioned in your postscript are in the department of the Coiner, by whom I am informed, that he has constant use for them *all.* The steel instrument you also refer to was made by the foreman of that Depart., assisted by one of the men for the use thereof, and properly belongs to the "machine shop."

J.M.K.

(F). Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana to John Leonard Riddell. June 26, 1840.

Sir,

I stated to you, some time ago, that I had laid before Dr. Patterson, the conflicting opinions of yourself and Mr. Tyler respecting your three or four last melts of gold, and had requested him to furnish me with some test by which I might judge of the fitness for coinage, of the ingots made by you for the Coiner, as I was myself unable to determine between you.

I thought however, and you will recollect, so said to you, that, with a view of paying off our gold debt, which had existed for some time, and was not very large, we might, in the meantime, in an amicable way, and without intending, whatever might be the result of our experiments, that either party should consider himself as having achieved a triumph over the other, succeed perhaps in working enough of the gold to accomplish that object.

I now find that the thing has taken a turn entirely different from any that I had ever intended, and that the issue of the trials which were to have been made yesterday morning, was to have the basis of a settlement by me of a question which I had already acknowledged my incompetency to pronounce, and which I had referred to the Director of the Mint at Phila.

Upon inquiring, at the Treasurer's office, I find that all the gold certificates that are out are in the hands of the Bank of La. of which Mr. Cammack is a Director, and am informed by that gentleman that the Bank is in no hurry for payments.

Under these circumstances I have two reasons for opposing any further attempts to work this gold, and waiting the decision of Dr. Patterson which we must now receive in the course of a very short time, and to which we must at last submit.

The first is that we have no *immediate* use for gold coins— The second, the entire absence *on both sides* of that spirit in which the operations were, as I hoped, to have been conducted, and the existence, between the officers interested, of feelings on the subject, which for the sake of the Mint should never have arisen, and to the aggravation of which it shall not be said that I have knowingly contributed.

Respectfully,
Y'obt Servt
J M Kennedy
Supt

Dr. J.L.Riddell
Melter and Refiner

(G). John Leonard Riddell to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. June 26, 1840.

Melter and Refiner's Office, New Orleans,
26th June 1840 2 p.m.

J M Kennedy Esq
Superintendent
Sir

I acknowledge the receipt of your note of this morning.

I cannot conceal the disappointment I feel in not having met you this morning at 10, as per your appointment, having had an opportunity agreeably to our conversation and your note of the 19th inst, to demonstrate the toughness and malleability of the gold ingots.

It is not a "triumph" which I wish to "achieve". I wish to establish a plain fact, and relieve myself from a false imputation. Our mint coins no gold. Depositors have withdrawn their deposits or sold their certificates at a discount. Public interest is suffering. The mint does not fulfill its destiny. The whole blame is laid by the coiner to my charge, and his assertion is received by many others who hear nothing expressed in opposition to it. You profess yourself to be unable to form an opinion, whether he or myself are in the wrong. The coiner reports to you the particulars of his *failing* to roll the ingots. But when asked for 10 minutes use of a pair of rollers — any one pair out of five or six in the rolling room, he at first frames trivial excuses and lastly informes me (note of June 25th) that you "wish no more experiments to be made until by your own direction."

Thus I am denied the ready and palpable means of eliciting truth and relieving my official credit. The plain path of duty is before me, and personal considerations shall never cause me to lose sight of what I owe to the government and the country. Had not the coiner in the commencement of this controversy, in your presence, assured me that he "perfectly understood the whole subject of gold ingots and wished for no hint or suggestion from me" the gold in question would ere now have been made into coins, and instead of a total cessation, large deposits of gold would still have been coming in.

Those ingots can be rolled in accordance with the directions from Dr. Patterson and I am ready to point out both by experiment and in writing, wherein the coiner fails: — and this I will do at any time, on your written command, accompanied with a pledge to see the same carried into execution.

All personal considerations aside (and no one shall be more forward to bury personal difficulties than myself) I deem it my duty as a public officer to make you the foregoing communication, the last but one on my part I hope, of the golden correspondence.

Respectfully,
Your ob't S't
J L Riddell
Melter and Refiner

(H). Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana, to John Leonard Riddell. July 2, 1840.

Sir,

I must correct a misapprehension under which you are labouring, arising from a note of the 25th Inst. rec'd by you from the Coiner.

He says to you in that note, upon your application for "ten minutes use of a pair of rollers" that "I wish no more experiments to be made until by my direction." Now Mr. Tyler could never have understood it to be my intention to interfere with any disposition which he might have to accomodate you with the use of a pair of rollers, whether for ten minutes only, or any other period, and I have so written to him — The postponement until after hearing from Dr. Patterson, had reference entirely to the experiments which were to have been made in my presence and that of the other officers of the Mint, and my reasons for ordering it I have already given you.

You will permit me to say, that your official credit has suffered more, in your imagination than any where else. I have never since the commencement of this controversy heard your capacity questioned any more than the Coiner's and if Mr. Tyler has, as you say, laid the whole blame consequent upon the want of gold coinage upon you, you have retaliated, and severely too, by saying that you believed he cracked your ingots designedly.

(An insert in Riddell's handwriting: (*) This however I have kept to myself.
Written on opposite page: (*) vide Letter J.)

In your note to me of yesterday, which I did not receive until this morning, you say you know why it is that Mr. Tyler fails — I am sorry that you have thought proper to *dictate* as you have done, the terms upon which alone you are willing to communicate the information.

Very respectfully your
Ob't Serv't
J M Kennedy
Supt

Dr. J. L. Riddell
Melter and Refiner

(I.1.) John Leonard Riddell to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana. July 7, 1840.

Sir,

I received yesterday for explanation from the Secretary of the Treasury, a copy of certain charges made against me.

They are as follows, viz:

(Here the charges were set down verbatim)

J.L.R. Parenthetic Insert

Permit me respectfully to inquire whether these charges were wholly or in part proffered by yourself. If but a part of them were made by yourself, be pleased to designate the same to me, and oblige

Respectfully your
Ob't Ser't
J L Riddell

(I). Joseph M. Kennedy to John Leonard Riddell, July 9, 1840.

Sir,

I have not until this moment had the leisure to reply to your two notes of the 7th instant, in one of which you inquire of me whether certain charges against you therein enumerated, and submitted to you for explanation by the Secretary of the Treasury were "wholly or in part proferred by myself."

This inquiry on your part has excited within me a feeling as well of nortification, as surprise, for I had flattered myself, that during six or seven months of daily official intercourse with me, I had afforded you opportunities enough of seeing, that it was not in my character, to make an attack in the dark. Had it ever entered my mind to prefer any kind of charges of which you have spoken, to *no one* would my intention have been communicated sooner than yourself. Three instances alone, if I remember right have occurred in which I have had occasion to mention your name to Dr. Patterson, in connexion with anything like an undesirable state of affairs in the Mint.

When I replied to his inquiries about the discharge of two of your workmen, my statement was *read* by *yourself* and approved as containing the exact circumstances of the case.

The second instance, grew out of the controversy between the Coiner and you about the *gold,* and the manner in which *that* matter was laid before the Director was submitted to, and recognized by, both that officer and yourself as correct.

The last was in obedience to an imperative duty, of which I apprized you at the time. It was the representation of your affair with McCarthy, given without word of comment upon your conduct, and for reasons with which you were by me made fully acquainted.

I cannot omit the opportunity now offered, of rendering to you the expression of deep regret I experience at the misunderstanding which has existed for some time between you and Mr. Tyler. The question appears to have grown into one of *qualification* of *skill,* in which the pride of each is exclusively involved — Hence, each one of you, in the full conviction that he is thoroughly acquainted with his own business, is unwilling to listen to any thing from the other, in the way of suggestion — this is a state of things to which I can foresee no end, so long as we have any metal, either to melt or coin, unless a feeling, which, with us all, should be stronger than any other, to wit, a desire for harmony and peace throughout the establishment, should bring about between you a better understanding founded upon a spirit of mutual concession.

I have never, to any one, given the slightest intimation that you had lost my regard. You have not done so.

Respectfully
Your Ob't Serv't
J M Kennedy
Supt

Dr
J.L.Riddell
Melter and Refiner

(J). John Leonard Riddell to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, La. July 11, 1840.

Sir,

I make here in writing an explanation, which you will remember, I did verbally, the day after receiving your letter of the 27th of June. You misunderstood a remark of mine while we were in private conversation. I said, that as I had rolled the gold ingots without difficulty, and could do it at any time, they must be cracked in the coining department, either through ignorance or design.

I *do not* wish to be understood as accusing the coiner of doing me such great injustice intentionally.

In brief reply to yours of the 9th inst. let me assure you that I desire peace. I have borne and sacrificed much in hopes of maintaining it, and will bear and sacrifice more if it can still be compassed.

I am no agressor: — I have made no complaints, — I have preferred no charges: — I have often said in relation to the coiner and myself, we are comparatively inexperienced; let us cherish a desire to cooperate; and if difficulties arise canvass them with a spirit of forbearance. Questions have arisen, and questions too affecting my skill or competency, yet I have still signified my willingness to receive and act on, any relevant suggestion from the coiner or any other source: or to submit the subject matter to any or every test, trial or reference. But have I been met on such open ground? In lieu thereof have I not been impeached at the seat of government? In justice to yourself

permit me to say that I never for a moment supposed that you were privy to this "attack in the dark."

In conclusion I will add that I am heartily tired of contention and will pledge myself to second any efforts to establish harmony.

Respectfully,
Your obedient ser't
J L Riddell

(K). Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, Louisiana, to John Leonard Riddell. July 11, 1840.

Sir,

It affords me pleasure to inform you, that I have heard from Dr Patterson, in reply to my letter giving him the circumstances alluding to the discharge of the two workmen from your Department, and that he expresses his satisfaction with the grounds assigned by you for their dismissal.

Resp'
Y' Ob' Serv't
J M Kennedy
Supt.

Dr. J.L.Riddell
Melter & Refiner

(L). Working of Gold Ingots

When the ingots have been tapped and filed, they are annealed by the coiner, after which they are formally delivered to him. The process of working them is then as follows:

1. They are rolled successively to the length of 2 feet, 4 or 5 inches — they are then annealed, and pickled exactly as another ingot.
2d. They are again rolled to the length of 3 ft 7 or 8 inches. They are next bent once, annealed and again pickled.
3d. They are then rolled to the proper thickness. Care must be taken in rolling, not to take too great a pressure at any time. The last time they are passed through twice, without altering the screws of the rolls.
4. They are now cut into two pieces, and each piece is bent into three; and to render them fit for drawing, they are again annealed and pickled.
5. Next they are pointed.
6. They are then heated until they can just be held in the hand, and in this state dipped into wax heated nearly to boiling. The wax being the best yellow beeswax, without tallow. After dipping they are laid upon a board prepared for the purpose, when they are turned backward and forward, for the purpose of chilling the wax, and distributing it equally over the surface. They are now ready for drawing and cutting. To enable the pointed end to enter the drawplate the point must be heated and this is best done by holding it on a copper plate, heated by a spirit lamp.

(M). Explanation of the cause of the coiner's failure in rolling the gold ingots, received by him since the middle of May, 1840. By J.L.Riddell, Melter and Refiner.

I will premise that the ingots previously rolled by him were all if I mistake not, of the kind called half eagle ingots, which are 9/10 or 18/20 of an inch broad by 9/20 of an inch in thickness. All delivered to him since have been at his own request quarter eagle ingots, which are 13/20ths of an inch broad, by 11/20th of an inch in thickness, in fact shaped like square rods. The latter require greater skill and knowledge to be properly rolled; for all workers in gold know well that it is easier to laminate successfully thin, flat ingots than such as are square or thick: and the reason of this will upon a little reflection appear obvious.

I will here set down some well established physical facts.

1st. "A gold wire 1/13 of an inch in diameter will sustain only 150 lbs Avoid." hence there is a limit to the strength of gold.

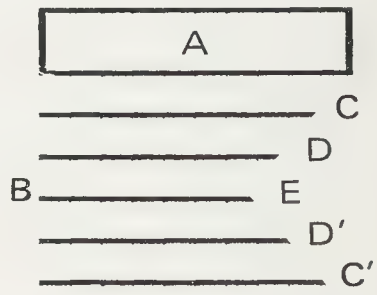
2nd. Standard gold ingots are one percent more dense or less bulky, after having been well hammered to laminated, than before.

3rd. The most ductile gold loses its ductility after having been beated or laminated to a certain extent, and can be made to recover it only by being heated or annealed, so as to loosen or lessen the forced cohesion among the particles. A red heat is the most proper temperature for annealing. Gold heated to near its melting point and suddenly cooled is rendered brittle. (Silliman's Chem. Vol. ii p. 350.)

I attribute the past failures in rolling the gold to improper annealing; for gold ingots as they are suddenly cooled from the melting point in being cast, are unfit for rolling until after they have been properly annealed; and any defect in that operation caused by heating them either too low or too high would be prejudicial.

But even supposing them to have been well annealed, they are still liable by bad management to be cracked in rolling; and to aid in explaining how this may happen, I will here detail two among many many experiments which I made in reference to the matter.

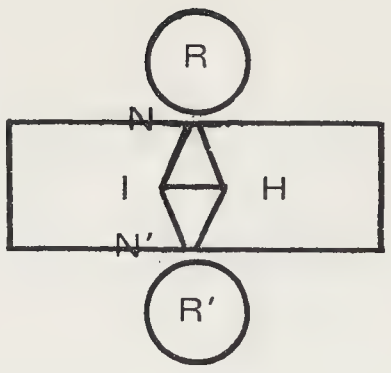
1st. Take say 5 slips of ductile sheet gold, cut of equal length in the form represented at A. Lay them upon each other in a bundle, with the ends even, as at B.



Beat them by delicate blows thus on an anvil with a light round faced hammer; or press them lightly and repeatedly between steel rollers. It will soon be observed that the outer slips C, C' elongate more rapidly than the slips D, D' and that the middle slip E is drawn out last of all.

2nd. Prepare 5 similar slips and beat them with a heavy hammer or pass them between the rollers with a heavy pressure, and they will all elongate equally.

Now in passing in ingot (PS) lightly between the rollers (RR') the rollers may be considered as exerting the compressing force in a progressive line, crossing the ingot where they come in contact with it (NN'). But towards the centre of the ingot the force becomes more diffused and less intense until at the centre it may be considered as extending from I to H, where it is far short of being adequate to compress the metal one per cent. In this way by repeated light rollings the surface becomes condensed and rigid, while the interior of the ingot is yet malleable and little affected.



In all Mr. Tyler's experiments as reported to the superintendent (vide N) this very condition of things obtained. I will take his experiment on Ingot No 1 as an example. Here he says "annealed" or "passed 11 times through the rolls, giving in all a half turn of the keys, and drawing about 2 inches in length." Let us suppose that by the time the ingot had been thus very lightly passed 5 times between the rollers a ribband of hardened, compressed inextensible gold 1/10th of an inch in thickness becomes formed on each rolled surface. Now on the 6th time passing through the malleable gold within is compressed and elongated and the surfaces have to bend to the rollers and elongate too. But as without annealing these hardened surfaces will bear no further extension, they necessarily crack and give way.

This could not happen if a bold pressure were given at first, sufficient to compress the whole substance of the ingot, 1 per cent in volume, beyond which it could not be rendered more dense. The whole would then elongate simultaneously, like the slips in my 2nd experiment before cited.

The very first time passing the ingot between the rollers a full quarter turn pressure or more should be given to it, instead of one sixths that pressure as in the coiner's experiments; and this should be followed by quarter turns, for several times successively, until a second annealing becomes necessary. In this way I have succeeded in rolling properly and without failure or fault, samples of every rejected melt of gold.

(N). P. B. Tyler, coiner, Branch Mint, New Orleans, Louisiana to Joseph M. Kennedy, Superintendent. June 23, 1840.

Dear Sir,

In answer to your letter of Saturday last I am sorry to say the gold ingots will not work in the ordinary way. At the time of receiving the ingots I was informed by the M & R that they had been annealed and hammered, and afterwards annealed and pickled by himself, and that they were ready for rolling.(*)

(*) Note by Riddell — The coiner here misunderstood me, as I immediately apprised him when I became aware of it. I had annealed for the purpose of pickling as our regulations require previous to delivery — not with the care requisite to prepare for rolling. J.L.R.

Upon this authority I thought I would roll some of them without first annealing them myself, but in attempting to straighten them from the crooks they had received in hammering, one ingot was accidentally broken, which led me to suppose that the others were equally brittle. I then tried them by striking across the corner of the anvil, and some of them broke with almost the brittleness of glass. I then took five (5) ingots indiscriminately from the lot, and passed them 6 times through the rolls, giving them 1/8th of a turn of the keys at each time, stretching them in lengths about two inches in all: at the very first time passing through the cracks could be seen very plain, which continued opening wider until the 6th time, when they had not lengthened more than two inches (notwithstanding the Directive inform that they should be successively rolled to the length of 2 ft 4 or 5 inches, before annealing the second time). Four or five more were then rolled in your presence with the same result, after which I received your note above mentioned. Not feeling satisfied to report upon them without trying some of my own annealing I stated the same to you and received in answer your request to make further trials.

I then took 3 ingots and marked them Nos. 1, 2 & 3, which I annealed and rolled as follows: No. 1 — not hammered — annealed at nearly red — dipped in pickle — passed 11 times through the rolls giving in all a half a turn of the keys, and drawing about 2 inches in length — cracked on the surface — annealed again at the same heat — pickled — rolled four times through — drawn one inch — cracked too bad to finish.

No. 2. — Hammered by the M & R — annealed at lowest red heat — rolled the same as No.1 — annealed at the same heat as at first — pickled — rolled again 4 times — drawn one inch — cracked same as No. 1.

No. 3. — Hammered by my foreman — annealed at cherry red — pickled and rolled same as Nos. 1 and 2, annealed at same heat as at first — pickled — rolled four times — cracked some the same as Nos. 1 & 2 — rolled 6 times, cracking more at each time.

I then took 4 ingots and rolled them to the usual length of 30 inches, at which length the cracks on the sides had nearly disappeared or drawn over each other, but the edges were quite rough. I then selected the worst and the best of the four, and annealed them at a moderate heat, then rolled them to the proper length for drawing: — the worst is entirely unfir for coins; the best would be subject to great waste in drawing, and if it could be drawn to the proper weight many of the pieces would be imperfect. I wish you to examine the pieces with which the experiments have been made, and if convenient, I should like you to witness some of the experiments as above. If then you should request me to make as much of it as

possible into coins, I will cheerfully do so, notwithstanding the great waste which must necessarily occur.

Very respectfully
Your faithful servant
P B Tyler,
Coiner

(O). John Leonard Riddell to Dr. Hort, Assayer, Branch Mint, New Orleans, Louisiana. July 9, 1840.

Sir,

The second charge preferred against me at Washington reads thus: —

"That you are giving bad ingots to the coiner and do not seem to be able to make them better." As you assay every melt of standard bullion made by me, be pleased to address me a statement as to the quality of the approved ingots both in silver and gold.

And further, as inquiry has been made by Dr. Patterson whether the dismissal of Mr. Levic from my employ on the 14th of March was not the immediate cause of defect in the gold ingots, be pleased to state how many melts of gold were made by me afterwards and rolled by the coiner without complaint.

Respectfully,
Your Ob't Serv't
J L Riddell
Melter and Refiner

(P). Dr. William P. Hort, Assayer, to John Leonard Riddell, July 9, 1840.

Dr. Sir,

I have recd your note in which you state that another charge preferred against you at Washington is

> "that you are giving bad ingots to the coiner and do not seem to be able to make them better."

It seems strange that so indefinite a charge should be brought against you. I have assayed for you 340 melts of silver ingots since you took charge of your department, all of which appeared to me to be sufficiently tough except a few melts cast about the last of March from a deposit of Mexican bullion made by Zacharie and Co. I reported those ingots as too brittle. About that time I heard that the coiner had rejected several melts of ingots, but as I had duplicate assay pieces in my possession, which it was proposed to send on to Philadelphia together with an ingot from each melt that might be rejected, complaint suddenly ceased. And I have heard none since; indeed I know that all the ingots since that time have been coined. The charge therefore cannot allude to silver ingots.

During the same time I have assayed for you 14 melts of gold ingots, three of which I rejected on account of the title; they all however appeared to me as far as I could judge from the operations carried on in my department, to be sufficiently tough. I am aware that from the time the coiner ceased complaining about the silver ingots that is since the 15th of May, 5 melts of gold ingots have been rejected. As the mint has suffered much on this account, from the inability to pay some gold certificates, and the consequent suspension of gold deposits, which before that time were flowing in very freely, I deeply regret that your proposition relative to the rejected gold ingots was not accepted. You had succeeded in rolling some of them, were confident that you could roll them all, offered to do it in presence of all the officers and resign if you failed. It appears to me that this was the simplest, shortest and easiest way of deciding satisfactorily which offer was in fault, and what remedy was necessary to correct the existing evil — At least as the proposition came from you, it seems but reasonable that you should be relieved from responsibility in the case.

In reply to your other enquiry I have to say that after Mr. Levick left your department I assayed and passed three melts of gold ingots on the 24th of March and 6th and 26th of April, which were successfully rolled and converted into coin, and repeat that it was only when the coiner's position became untenable in reference to the silver ingots, that the gold ingots were rejected.

I remain respectfully,
Your friend
Wm P Hort
Assayer

J L Riddell MD
Melter & Refiner

P.S. Recollecting that you informed me that one of the charges brought against you was "that you have lost the regard of your fellow officers"

I take this opportunity to assure you that you have not lost my regard; On the contrary my respect and esteem for you have increased as I have become better acquainted with you; and I am persuaded that the office you fill could not be better supplied than it is at present; I speak this positively from a knowledge of your scientific attainments, and practical skill as a chemist.

&
Wm P.H.

(Q). John Leonard Riddell to P. B. Tyler, Coiner, Branch Mint, New Orleans, Louisiana. June 23, 1840. 8 a.m.

Sir,

I have a favor to ask, for which in good faith I shall be happy to reciprocate anything in my power. I wish for twenty minutes opportunity of using some one pair of rollers in the rolling room, in order to put certain theoretical idea of mine to the test of experiment. They have relation to the toughness of gold, and I shall be happy to have you present if you think proper.

Permit me to add, that as the great interests of the public require a cooperation among the officers of public institutions I shall ever hold myself in readiness to canvass such difficulties as arise between us with a spirit of accomodation, and a sincere desire to arrive at truth.

The favor of an immediate reply is requested.

Respectfully,
Your Obt.Sert.
J.L.Riddell
Melter and Refiner

(Q.2). Philos B. Tyler, coiner, Branch Mint, New Orleans, Louisiana to John Leonard Riddell, June 23, 1840.

Sir,

I received your note of this morning to which I reply.

That a series of experiments are now going on in the rolling rooms for the purpose of ascertaining if the gold which was delivered to me on Saturday last, can be worked into coin, in conformity with the law.

If after those experiments are completed my report upon the same, does not cover the whole ground of your inquiry, I shall be happy to comply with your request of this morning, notwithstanding your direct refusal (*) a few days since, of my using one of your melting furnaces in some experiments of the same nature.

Permit me to add that I have a great desire to cooperate cordially with the officers of this institution, and no one can be more ready to adjust any difficulties which may arise, or more sincere in the desire to arrive at the truth than myself.

Respectfully
Philos B. Tyler
Coiner

(*) See over.

(*) I gave Mr. Tyler full permission to use my furnaces, pots, & by himself or his workmen, for the purpose of experimenting on bullion in *his own custody;* but declined having him operate thus on bullion in my custody; thus never denying him favors similar to the one which I vainly asked of him.

JLR

(Q.3). John Leonard Riddell to P.B.Tyler, Coiner, Branch Mint, New Orleans, Louisiana. June 24, 1840. 2 p.m.

Sir,

As your experiments are completed, and your report thereon in the hands of the Superintendent, I would now ask the favor of being permitted for my own gratification, to use a pair of rollers for half an hour this afternoon, in experimenting on some bullion in my custody.

Please reply immediately.

Yours respectfully,
J.L.Riddell
M.& R.

P.B.Tyler,Esq.
Coiner

(Q.4). P.B.Tyler, Coiner, Branch Mint, New Orleans, Louisiana to John Leonard Riddell. June 24, 1840.

Sir,

I have just received your note of this afternoon, In the reply to which I would state that the rolls will not be in operation this afternoon, and that I have an engagement with the Supt. tomorrow morning by which they will be occupied until those experiments which I spoke of my last are completed – I think they will be at your command at 10 o'clock.

Respectfully,
P.B.Tyler,
Coiner

(Q.5). John Leonard Riddell to P. B. Tyler, Coiner, Branch Mint, New Orleans, La. June 25, 1840.

Sir:

As the rollers are now in operation, you will excuse me for asking to be permitted to use a pair a few minutes; for at 10 o'clock and after I shall be absent and indispensably engaged.

I wait your reply.

R Respectfully,
Your Obt. Sert.
J.L.Riddell
M&R

(Q.6). P.B. Tyler, Coiner, to John Leonard Riddell. June 25, 1840.

Sir

I am now using the rolls myself in the experiments which I stated to you last night.

P.B.Tyler

Note: It is worthy of recollection that as Mr. Tyler could use but one pair of rollers, any one of the four idle pairs would have answered by use.

J.L.R.

(Q.7). John Leonard Riddell to P. B. Tyler, Coiner, June 25, 1840, 3:30 p.m.

Perhaps it would suit your convenience to spare me a few minutes use of a pair of rollers just now. I shall feel quite obliged to you if such is the case.

Respectfully,
J.L.Riddell
M&R

(Q.8). P. B. Tyler, Coiner, to John Leonard Riddell, June 25, 1840, 4:00 p.m.

Sir,

I have this moment received your note, but had previously given orders to stop the engines at 4 o'clock.

Mr. Kennedy informed me this morning that he desires no further controversy between us – and wished no more experiments to be made until by his direction.

Respectfully,
P.B.Tyler,
Coiner

(R). Dr. James Jones to John Leonard Riddell. July 8, 1840.

Dear Sir–

I observe that serious charges have been made

against you particularly in relation to having inflicted personal and well merited chastisement upon John McCarthy, formerly employed by you in this mint. It is perfectly true that this act has subjected you and those whom you invited to witness to a criminal prosecution — but I have to learn for the first time that it has brought disgrace upon the establishment of which you are an officer — Indeed by the universal opinion and custom of this community the only disgrace would have been to permit a man who has assiled your public and private character to go unpunished. McCarthy stated to me and to others that you were dishonestly appropriating the publick property committed to your charge — that you had disposed of the bullion at a premium — which if called on suddenly you could not explain and that by reason of incompetency added to this an examination into the contents of your vaults would prove you to be a defaulter — to the public injury and to the ruin of myself and others who were on your bond. (I was present at the investigation made by your request by the Treasurer and Superintendent and I have only to add that I was as well satisfied as they were that you had in your possession everything intrusted to you).

This McCarthy further disclosed that not only were you incompetent and dishonest but contemptible and cowardly — that he had demanded personal satisfaction of you for certain alleged insults — and to use his own expressive language

"had made you hang your ears like a dog."

He did not even hesitate to disclose that he knew of occurrences in relation to a member of your own family repugnant to everything honorable and humane.

I will only add that all your relations with McCarthy previously to this occurrence were those of a preceptor and benefactor and that in inflicting upon him this chastisement he took so much trouble to cause I am compelled to declare that I knew you to have been actuated more by the advise and influence of your friends both within and without the mint than by any personal feelings of your own — and that although his own vindication, feelings and probably the motives of others have made this the ground of a serious charge upon your official standing—that few men in this community would have treated him with so much moderation.

Your obedient servant,
James Jones

(S). John Leonard Riddell to Dr. R. M. Patterson, Director, United States Mint, Philadelphia, Pa., June 28, 1840.

Sir,

Mr Kennedy showed me yesterday a letter received from you, written in consequence of an exaggerated report of an assault on John McCarthy having indirectly reached your ears. The particulars

> "McCarthy being at the time employed in the mint, was brutally assaulted with clubs, bowie knives, etc. and that the mint had stopped in consequence of the offending parties, having been bound over to court."

I quote from your summary and may be partly incorrect.

In consequence of the inquiries you make of Mr Kennedy I deem it my duty, though unasked, to lay the leading circumstances before you.

I apprised you in my last letter, that in consequence of his persevering importunity and from charitable considerations I had admitted McCarthy to a laborer's station in my department. He became deeply disaffected because I found him unworthy of promotion, and implicated himself and others in plots to injure me. Having been a student of our medical college I was loath to discharge him, but earnestly and repeatedly advised him to find some other employment. He was well aware I had lost confidence in him. On the 26th of May at noon, refusing to file a saw, he quit work, informing me that he no longer considered himself as belonging to my department. He then set about publishing in the community the vilest slander he could invent. He made statements to my securities which determined me to expose my vaults to inspection. He then caused the publication in the Sun newspaper which you have seen; heading it "Rather suspicious, alias Melting and Refining." That his conduct was insupportable and aggravating in the extreme, will appear by the following written statement of Dr. James Jones, one of my securities, a gentleman of high standing. Immediately after leaving the mint, McCarthy called on him.

(Riddell note: Here followed a detailed statement of the slanders since condensed by Dr Jones into the accompanying letter by him, which see above, Marked R).

It is perhaps to be regretted, but public opinion in this climate, as you are doubtless aware, sanctions and under similar circumstances, requires a resort to personal chastisement for slander like the above, so bare, so palpable and so utterly unfounded in truth.

McCarthy was no longer connected with the mint. The medical college of whose faculty I am a member had conferred the degree of Doctor of Medicine on him, which alone gave him a claim to respectability. My friends, among whom were Messrs. Kennedy and Cammack, warmly urged me to chastise him; and this I did on the piazza of his boarding house, having in company with me two individuals who took no part, to mark that I neither used nor displayed any weapons, more formidable than my flat hand. This was on the first of June. When I had thus rebuked the slanderer, my conduct was cordially approved by Messrs. Kennedy, Cammack and Hort, and all who knew the circumstances, and the tone of public feeling.

It is true, in McCarthy's complaint I have since been convicted in the Criminal Court of assault and battery, and am defendant for a civil action for damages based on the same. In the civil action a reconvention for slander will be allowed, and mitigating testimony will be received in the criminal court, where the judge declines pronouncing sentence until after the civil action shall have been decided, say perhaps two years hence. The judge of the criminal court assures me that as my

presence is indispensable at the mint, if after he shall have heard the mitigating testimony — concerning the slander which led to the assault — he shall then find it his duty to visit me with a severe sentence, he will do by a fine instead of imprisonment.

In conclusion then, let me remind you that the assault *did not take place in the mint,* that McCarthy at the time was *disconnected from the mint,* — that my provocation was beyond human endurance — that my friends and impartial persons sustain me in what under the excitement of the moment I did: — and that great allowance must be made in estimating a summary act, required by the tone of public feeling in a community. If under the excitement of deep injury I transgressed the strict law of the land, I hold myself amenable to that law, and shall abide its penalty.

Respectfully your
obt sert
J L Riddell

(T). John Leonard Riddell to J. Bertrand, Weighmaster, United States Branch Mint, New Orleans, La. July 10, 1840.

Sir,

I take the liberty of inclosing you a copy of charges preferred against me at Washington city. As during the daytime you have been constantly at your post in the weigh room, and have exclusively attended to the transfers of bullion; and as, therefore, better than any one else, you can appreciate the merits of some of their charges, you will pardon me for asking from you such comments thereon as you may please to make; especially in regard to my disturbing the peace of the institution.

Yours respectfully,
J.L.Riddell

(U). J. Bertrand, Weighmaster, United States Branch Mint, New Orleans, La. to John Leonard Riddell. July 13, 1840.

Dear Sir,

I have received your note of the 10th inst accompanied with a copy of certain charges, preferred against you at Washington City.

In answer to the first charge, I will say that during the 9 or 10 hours that I remain daily in the mint, attending to my duty, and having frequent access to your department I have never seen, nor heard of any quarrel between you and any workmén in your employ. That some have not done their duty, I know from personal observation, and as to the dismissal of one certain McCarthy, I will observe, that I happened to be present (and you not in the melting room at the time) on or about the 25th of May when one of your workmen, named King, very active and quick, turning out the Ingots from the moulds, faster than he (McCarthy) could put them up, caused said McCarthy to get into a violent passion. He (McCarthy) then observed that he could not stand at such work, and said "I be d..d if I continue in the Mint any longer."

The next day, he came to my office, and asked me

"if Dr Riddell had left his account, that he wanted to receive his pay."

I answered no, and that I had nothing to do with his account, nor with Dr. Riddell respecting it. He then commenced some abusive language towards you, when I ordered him out of my office.

In all the controversies that have existed between you and the coiner, in my presence, you have shewn at all times, that spirit of moderation and a natural disposition to sacrifice all self-love, to arrive at the truth, which should always be the characteristic of a gentleman, and especially of an officer, under oath to protect and defend the interests of the Government. I will further observe, that I do not know of any circumstance that has taken place in which you could have been the cause of retarding the operations of the Mint.

In answer to the second charge, I will remark that I cannot constitute myself judge of the good, or bad quality of silver and gold ingots. This decision can be given only by the Assayer. But, however, I think it proper to observe that during the month of March last nearly 20,000 ounces of silver ingots, partly rolled, were returned by the Coiner, for the assigned reason, that they were not fit to be rolled for coinage. This created the first difficulty which took place between you and the Coiner. You appeared to be so well convinced that they were fit to be wrought, that after receiving the same from the Coiner, you requested the Superintendent to take out a Sample of the Strips returned to be forwarded to the mint at Philadelphia. I am ignorant of the steps taken respecting this difficulty and of any decision on the subject; but since that period, there has not been a single complaint made by the coiner, respecting silver ingots. In reference to the difficulties that have arisen about gold ingots I have given my views in the answer to the first charge; but I must here state that, to satisfy both parties, and at your own request, the Superintendent decided to send on to the Mint at Philadelphia one or two Ingots of this last make, in order to have this matter decided there.

In answer to the third charge, I will say that I was present at the trial before the Recorder, and that not a single witness testified that you had severely beated McCarthy. One only named Ernst (who had been in your employ sometime previous and dismissed) declared that he saw you when you took him (McC) by the hair, and struck him a blow behind the head with your hand. The reason you took two persons with you was mentioned at the time. It was to prove that you did not attack McCarthy with any weapon, because you were certain that he (McC) would make an affidavit, declaring that you intended to kill him.

Far from having brought disgrace upon the mint your conduct has been approved by everyone who knows you and by the Superintendent himself. The only regret your friends have, is, that you did not give him that chastisement, which his vile and infamous conduct towards you so justly deserved. I might have given you more particulars, in answer to the questions put to me; but I think

the above explanations will be sufficient for the present.

Respectfully,
Your friend and Servant
J. Bertrand
Weigh-master

(V). John Leonard Riddell to J. M. Kennedy, Superintendent, United States Branch Mint, New Orleans, La. June 22, 1840.

(Here followed a plan for a filing machine)

The successful introduction of the large pot in melting silver renders this improvement necessary. This pot can now be inspected after just one month's use, in the course of which time, twelve melts have been made in it, equal to 150,000 standard ounces. Not an ingot has been condemned by the assayer, or found fault with by the coiner. I can constantly and with ease make one melt a day of 13,000 to 16,000 ounces net, amounting to more than 338,000 ounces monthly. With the filing machine in operation, I can if required double that amount, or furnish ingots for a silver coinage of more than $4,000,000 annually.

I should suppose from present appearances the pot would last three or four months longer, in everyday use.

On the plan pursued in melting when I came into the mint, a small pot seldom lasted to melt more than 8 or 10,000 ounces of ingots, and often bursting and spilling the silver in the fire.

Thus great economy attends the use of the large pot not only in the expense of the pots themselves, but in fuel, wastage of silver, labor, etc.

Another important result attainable by the large pot, is strict uniformity of standard of the coinage.

Respectfully,
Your Ob't Servt
J L Riddell
Melter and Refiner

(W). Extract of a letter from John Leonard Riddell to Dr. R. M. Patterson, Director, United States Mint, Philadelphia, Pa., June 8, 1840.

After detailing the difficulties with respect to the gold ingots, and exactly my mode of preparing them I add

"If I am wrong in opinion or deficient in knowledge of the matter I beg as a personal favor, and as a consideration of, similarity in our tastes and former pursuits, that you will frankly set me right and communicate such useful information as your superior knowledge and long experience will enable you to do."

I have received as yet (July 14) no direct reply. But in a letter of June 27th to our superintendent, Dr. Patterson says

"The process followed by us (in making gold ingots) was explained in a communication formerly sent to your mint, and which I presume came into the hands of Dr. Riddell."

It never came into my hands.

The Doctor then after giving a "general view" of the matter concludes by saying that he had made the charge against me as to the ingots "on which however," says he "I do not lay any great force, unless it may be shown that the ingots being bad he has refused to amend them."

Letter #13

John Leonard Riddell to Hon. Levi Woodbury, Secretary of the Treasury, July 18, 1840.

Sir,

On the 15th inst I mailed you my reply to charges preferred against me – with accompanying documents. Ere this reaches you, I trust you will have received that.

I take the liberty of inclosing a copy of a letter from Dr. E. H. Barton to the Director of the Mint, on the subject of the McCarthy Outrage. Permit me to add that Dr. Barton, late professor of the theory and practice of medicine, stands in this city at the head of his profession. No one is more generally and deservedly respected.

With great respect I
subscribe myself
Your obt Servt
J.L.Riddell

Notation: Send this with other papers to the Director. W.

Letter #14

R. M. Patterson, Director of the United States Mint, to Hon. Levi Woodbury, Secretary of the Treasury, July 27, 1840.

Sir,

I have the honor to acknowledge the receipt of your letter of the 25th inst transmitting a communication from Dr. J. L. Riddell, in reply to, and explanation of, the charges preferred against him as Melter and Refiner of the Branch Mint at New Orleans, together with the documents which accompanied it.

I have given careful attention to these documents, as well as to other communications received by me on the same subject; and I proceed to communicate to you the impressions left on my mind.

First, as to the attack made on MacCarthy, though I still think it most improper and ill-advised, I must acknowledge that the provocation was very great, and Dr. Riddell's letter to me of the 28th of June, presents a feature in this quarrel unknown to me before, and which is calculated to soften the judgment as to his course. I allude to a slander uttered by MacCarthy against Dr. Riddell, which was of an exclusively personal character (unconnected with the Mint) and which was no doubt as false as it was infamous.

As to the gold ingots, I have to remark that the details of the trials made on them by the Coiner can lead to no other conclusion than that they were not of a proper degree of ductility and it now appears that Dr. Riddell was, in fact, not aware of the difficulty of making the alloys of gold ductile, and was not acquainted with the process to be followed for this purpose. I had supposed that all our former instructions were on file at the New Orleans Mint, but it seems that this is not the case.

The omission, in the present case, has been already supplied, in a manner which I presume to be sufficient, but a copy of the original instructions shall also be sent.

With Dr. Riddell's reasons for the discharge of his men I have been made acquainted by the Superintendent, and I think that they were satisfactory.

It is a great misfortune to the New Orleans Mint, that the Melter and the Coiner should be on terms of misunderstanding. Mr. Tyler is probably not blameless in this matter, but neither, certainly is Dr. Riddell, whose course shows too much of an unconciliating disposition. Mr. Cammack says of him — "he has not succeeded in preserving in the Mint that harmony and good feeling so much to be desired, and without which its operations must be retarded and the situation of the other officers rendered unpleasant." Mr. Kennedy, in his letter to Dr. Riddell, of the 9th inst, says "I cannot omit the opportunity now offered of renewing to you, the expressions of the deep regret I experience, at the misunderstanding which has existed for some time between you and Mr. Tyler. The question appears to have grown into one of qualifications or skill, in which the pride of each is exclusively involved. Hence each one of you, in the full conviction that he is thoroughly acquainted with his own business, is unwilling to listen to any thing from the other in the way of suggestion. This is a state of things to which I can foresee no end, so long as we have any metal either to melt or coin, unless a feeling which, with us all, should be stronger than any other, to wit, a desire for harmony and peace throughout the establishment, should bring about between you a better understanding founded upon a spirit of mutual concession." With such proper views entertained by the officer who has the immediate control of the New Orleans Mint, with the knowledge that disputes among the officers brought that Mint, but a short time ago, to the verge of ruin — and has now given rise to so much trouble and confusion as to be one of the causes requiring the interference of the government, I hope that a better spirit will be cherished among them for the future, and that this source of complaint may be removed.

On the whole, though the evidence shows that there has been want of prudence and sound judgment in Dr. Riddell's course, I do not think that there remains sufficient cause for any further action in this case, on the part of the government.

Very respectfully,
Your faithful servant,
R. M. Patterson
Director

PS I return you all the papers as you desire.

Letter #15

R. M. Patterson, Director of the United States Mint, to Hon. Levi Woodbury, Secretary of the Treasury. July 29, 1840. Marked "Confidential".

Sir,

I have the honor to acknowledge the receipt of your letter of the 27th inst.

I had received Dr. E. H. Barton's letter, and had answered it. His defence of an appeal to muscular force in support of moral and official integrity may receive favor among certain portions of the community with which he associates, and may be dignified by the name of public opinion, but such conduct is not the less a moral deformity, and will never receive my approbation, or I am sure I may add, yours. The slander to which I alluded in my communication to you sent yesterday (and which I would not repeat in a public document) was an assertion by Dr. MacCarthy that Dr. Riddell had been the murderer of his wife, who died not long since at the Mint. For so gross a personal offence, a man may be driven to take personal *vengeance,* and I should not be disposed to pass heavy judgment upon his conduct. I should not be so absurd, however, as to think he has raised his *character* by it.

Mr. Kennedy, in a letter of the 12th inst., writes as follows:

> "Mr. Tyler, I am happy to inform you, has been able to work about $8000 of the last melt of gold. Dr. Riddell requests me to say that the process followed by you in the preparation of gold, and which was explained, in your words, in a communication formerly sent to this mint, has never come to his hands. He has taken a copy of the general view of it which you have given me in yours of the 27th ult., I trust we shall now get along better."

The first part of this extract requires explanation, for which I shall ask. Neither the language nor the amount would lead me to think that the whole melt was rolled. The quantity would make about a third or a fourth part of one of our melts. Was the remainder unfit for rolling? This could only happen from bad casting, but with inexperienced hands it may have occurred. When casting quarter eagle ingots we have generally to interrupt the operation in the midst, to cover the pot, and give a greater heat to the metal. If this be neglected, the ingots will be spoiled. Besides, it may be possible to roll ingots, by small degrees and frequent annealing, which a coiner might, notwithstanding, be justified in rejecting.

The last part of the extract convinces me that the melter was not acquainted with the process to be followed, in order to make ductile alloys of gold. In one of his letters he asserts that the gold must have been ductile because the ingots were made of fine gold obtained from the process of parting. Nothing can be more fallacious than this inference. If perfectly ductile fine gold be melted down with perfectly ductile copper in the proportion necessary to bring it to our standard, the ingots thus formed will always be found brittle — sometimes exceedingly so. This is one of the mysteries of the art, which I am unable to explain and of which Dr. Riddell seems to have been ignorant. — I take the liberty of sending herewith a copy of my letter to Mr. Kennedy of the 27th ult. a perusal of which will show you how naturally all Dr. Riddell's difficulties as to the ingots may have arisen.

As to the question of Mr. Tyler's competence and fidelity, I must refer you to my letter of the 21st of March and 22nd of April, the latter enclosing a letter from Mr. Kennedy, and a note from Mr. Cammack. I hear that Mr. Tyler has inherited from his brother the enmity of some individuals connected with the former regime of the New Orleans Mint, and that they are using their exertions to injure him, without just and sufficient cause. Mr. Tyler and Dr. Riddell are both deficient in experience, but they have the general knowledge of their respective departments, and the requisite talent, to make them good officers, if they can only be encouraged to cooperate together in peace. I have urged it upon Mr. Kennedy to use every exertion to bring about this most desirable end.

Very respectfully,
Your faithful servant,
R.M.Patterson

Notation on letter:

M 33 July 30 Secretary.
Check and return this to me for the Rdt. W.

Letter #16

John Leonard Riddell to Hon. Thomas Ewing, Secretary of the Treasury. April 8th, 1841.

Sir,

Aware as I am how completely your time must be absorbed in important matters, I would not obtrude myself upon you had I not observed this morning in one of our less respectable city papers, an article wherein I was mentioned among others as being obnoxious to Mr. Webster's late circular. — falsely charging me with having been an active partisan during the late Presidential election, and having influenced the votes of the men engaged in my department.

In regard to my having been an active political partisan you will excuse me for informing you that my attention has heretofore for years been wholly devoted to chemistry, botany and geology, without paying the least attention to politics. In the fall of 1839, while absent from the country, unsolicited by and unknown to me, the office of melter and refiner in the New Orleans Mint, was conferred upon me by Mr. VanBuren, at the instance of my fellow proffessors in the Medical College of Louisiana; they supposing me peculiarly qualified for its duties. I have never since, as a rigid investigation would prove, sought to influence the vote of any one in the elections. As to the men employed in my department I never inquired how they intended to vote, nor whether they voted at all. I never knew the political sentiments of any of them but my foreman who is a warm whig. At the instance of a friend on one occasion last summer, I was present at a small ward meeting of some 20 persons, the only political meeting I have attended since holding this office. Even then I made no expression of sentiments, public or private, for the matters in contest were foreign to my usual train of inquiries.

Having reason to believe that there may be applicants for the office I hold, who, though unqualified, are nevertheless willing to hazard the interests of government in undertaking the difficult and responsible business of melting and refining precious metals, I have deemed it a duty both to myself and the government to address you. Since accepting this office it has required my whole attention and study to quality myself for the satisfactory discharge of its duties, which, frankly, I found impracticable along at first. My men, at first inexperienced, are now progressively becoming better trained, and I am habitually finding occasions for making improvements in the mode and economy of the operations. In short, I now feel confident in being hereafter able to conduct the department under my charge to your entire satisfaction.

Being unknown to you, I take the liberty of sending you, as corroborative of some of my statements, sundry papers on the botany and geology of Ohio, researches made by me while residing in that State.

Allow me to add in conclusion, that as in accepting and devoting myself to the post I hold, I have necessarily got somewhat out of my former round of pursuits yielding a livelihood, especially the cultivation of natural history, and the accomplishing of mineral surveys, I will thank you to communicate to me at the earliest day permissable, the intentions of the President in respect to this office, in order that, if to be displaced I may secure favorable opportunity for making arrangements for the future.

Respectfully,
Your Obedient
Servant
J.L.Riddell
Melter and Refiner

Letter #17

Silas Reed to Hon. Thomas Ewing, Secretary of the Treasury. April 29, 1841.

Sir,

If you have no conclusive evidence that Doct J L Riddell, present refiner at the U S Mint at N.O. has been a political partizan and in that way prostituted the official trust reposed in him, I hope he will be continued in office. He is a gentleman of high literary and scientific attainments — of good moral character, and a business, industrious man. In point of qualification, industry and integrity, I apprehend no one in his superior. I knew him several years in Cincinnati — and his name in honorably connected with the botany, geology and mineralogy of the West.

I have the honor to be
With high regard
Your Obt Servt
Silas Reed

Letter #18

John Leonard Riddell to J. M. Kennedy, Superintendent, United States Branch Mint, New Orleans, La. May 21, 1841.

Sir,

The employment of slave labor in the melting department of this Mint has, for a considerable time, been a subject of reflection with me, and I am convinced that its partial introduction is practicable and would be attended with good results.

The following are some of the reasons as they present themselves to my mind in favor of employing slaves:—

I have in my department five hands, viz:— two foremen and three laborers. These three laborers are employed in carrying coal, tending furnaces, cleaning out ash pits, cleaning and handling moulds, lifting pots from furnaces, sweeping, filing ingots, etc. services which could at all times be just as well performed by blacks as by whites, and in the hot months of the summer much better, since Creole blacks can stand heat in this climate, or endure to work over hot furnaces far better than whites. White workmen may generally wish to leave during the summer, which if it does not wholly suspend, surely cripples the operations of the mint.

By permitting the employment of three slaves the government would save $20 a month on each, equal to $60 on the three or $720 a year, since, besides a deduction from present prices of $15 on the monthly wages of each it would be unnecessary to allow pay for their overtime.

By this means the custody of the bullion in process of melting or refining would be rendered perfectly safe, which I cannot consider it now, and this consideration with me is paramount to all others. Thus: a rigid police might be easily maintained over slaves, which would prevent the possiblity of robbery. The clothing of the slaves could be purposely simple and without pockets. They should never leave certain circumscribed premises until the closing of work at night, when their clothes should be changed in a room previously locked, in the presence of a foreman. All this would be impracticable with white laborers. They will not submit to these restrictions, nor is it to be asked of them. At present I have to trust to the honesty of my men, which I have it is true no special reason to doubt, yet day by day for weeks they might carry off bullion almost unsespected and thus involve me in ruin. Knowing this possibility I confess I am very often I may say almost incessantly annoyed by uneasy, though I hope groundless, apprehensions.

I am informed that for some time past the melter and refiner of the Dahlonega Mint has employed slaves as laborers.

In conclusion the pith of the matter may be laid bare in few words: By availing ourselves of slave labor in the melting department

1st We should almost do away with the danger of suspension in the summer on account of unhealthiness of the climate as occasioning the sickness or emigration of the laborers.

2nd We should annually save $720 in pay for laborers.

3rd and last, by placing these slaves under the control of a vigilant and confidential foreman my mind would be set at ease as regards the robbery of bullion, by almost preventing as I conceive the possibility of its occurrence.

I subscribe myself
respectfully
your obedient servant
J L Riddell
Melter and Refiner

Letter #19

John Leonard Riddell to John Tyler, President of the United States. November 6, 1841.

Sir,

Having had the honor and pleasure of becoming slightly known to you, while journeying westward from Washington City a year since, I am encouraged to address you at this time.

I have reason to believe that an attempt has been or will be made to prejudice my standing with you; for no other real reason than that I have disobliged some of my late friends by refusing to loan money: — but for the falsely alleged reason that I have not made a satisfactory settlement of my silver account.

There is it is true a difference of opinion between the superintendent of this mint and myself, respecting one item which in accordance with our regulations I offer: — viz, an estimate of nearly eight tons of sweep, or precious metal in ashes, etc. I wishing to save myself from loss by extracting the silver from it at this mint, which, having prepared myself, I pledge myself to do by the time of our annual settlement, the 1st of January; the superintendent on the other hand, refusing for the present to receive the assayer's certificate of its net value in settlement (1654 7/100 ounces of standard silver, near $1800, its gross or real value being near $3000) and wishing to have it sold at once to smelters abroad and the market value or nett proceeds (1654 7/100 oz) carried to my credit when received; by which, though the account would be closed, I would sustain a personal loss of more than $1000, of silver coins already advanced by in settlement. The whole matter is now before the Director, Dr. Patterson, at Philadelphia.

Should charges or complaints worthy of your notice from any source be preferred, I would surely ask an opportunity of being fairly heard in defence; and this I feel assured you will grant me.

I have the honor to be
with respect
your obt and humble
servant
J L Riddell
Melter and Refiner

Letter #20

From Robert J. Walker, Secretary of the Treasury, to John Leonard Riddell, December 4, 1848.

J. L. Riddell, Esq.

I am directed by the President of the United States to inform you that your services are no longer required as melter and refiner in the Branch

of the Mint of the United States at N.Orleans and that you are removed from that office.

Very respectfully,
Your obt Servt
R.J.W.
Secretary of the Treasury

Letter #21

From Robert J. Walker, Secretary of the Treasury, to Joseph M. Kennedy, Superintendent, Branch Mint, New Orleans, La., December 4, 1848.

Sir,

You will deliver to Mr. Riddell the inclosed letter and take care that the duties of the melter and refiner are no longer performed by him.

It is expected that this office will be filled in a few days by a new appointment, and in the mean time you will take such steps as will prevent any injury to the public interest.

Very respectfully,
Your obt servt
R.J.W.
Secretary of the Treasury

Letter #22

Washington and New Orleans
Telegraph Line

(murphy Print)

The following Communication was received at Washington 20th 11 o'clock 0 min p.m. dated New Orleans 20th 9 o'clock 20 min. P.M. for Hon Jeff Davis.

Professor J L Riddell competent and responsible, will accept our mint treasuryship. Please telegraph me where it is too late to forward recommendations.

Geo. Dunlap

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Volume 4: March 25, 1832 — Pittsburgh, Pennsylvania to August, 1832 — Marietta, Ohio
Volume 5: August 10, 1832 — Marietta, Ohio to August 30, 1832 — Marietta Ohio
Volume 6: Missing
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Volume 15: June 9, 1836 — Cincinnati, Ohio to December 15, 1836 — New Orleans, Louisiana
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The Riddell Mint Correspondence

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I. Appendix Material

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2. June 13, 1840. Robert M. Patterson to Joseph M. Kennedy.
3. June 13, 1840. JLR to Levi Woodbury.
4. June 16, 1840. Robert M. Patterson to Joseph M. Kennedy.
5. June 6, 1840. Joseph M. Kennedy to Robert M. Patterson.
6. June 18, 1840. Robert M. Patterson to Joseph M. Kennedy.
7. June 19, 1840. Robert M. Patterson to Levi Woodbury.
8. June 20, 1840. Robert M. Patterson to Levi Woodbury.
9. June 27, 1840. Robert M. Patterson to Joseph M. Kennedy.
10. June 18, 1840. JLR to Martin VanBuren.
11. June 24, 1840. Levi Woodbury to JLR.
12. July 14, 1840. JLR to Levi Woodbury.
    A. JLR to Joseph M. Kennedy, April 20, 1840.
    B. JLR to Joseph M. Kennedy, April 23, 1840.
    C. JLR to Joseph M. Kennedy, June 9, 1840.
    D. JLR to Joseph M. Kennedy, June 18, 1840.
    E. Joseph M. Kennedy to JLR, June 19, 1840.
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    H. Joseph M. Kennedy to JLR, July 2, 1840.
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    I. Joseph M. Kennedy to JLR, July 9, 1840.
    J. JLR to Joseph M. Kennedy, July 11, 1840.
    K. Joseph M. Kennedy to JLR, July 11, 1840.
    L. Working of gold ingots.
    M. Explanation of the cause of the coiner's failure in rolling gold ingots.
    N. Philos B. Tyler to Joseph M. Kennedy, June 23, 1840.
    O. JLR to William P. Hort, July 9, 1840.
    P. William P. Hort to JLR, July 9, 1840.
    Q. JLR to Philos B. Tyler, June 23, 1840.
    Q-2. Philos B. Tyler to JLR, June 23, 1840.
    Q-3. JLR to Philos B. Tyler, June 24, 1840.
    Q-4. Philos B. Tyler to JLR, June 24, 1840.
    Q-5. JLR to Philos B. Tyler, June 25, 1840.
    Q-6. Philos B. Tyler to JLR, June 25, 1840.
    Q-7. JLR to Philos B. Tyler, June 25, 1840.
    Q-8. Philos B. Tyler to JLR, June 25, 1840.
    R. James Jones to JLR, July 8, 1840.
    S. JLR to Robert M. Patterson, June 28, 1840.
    T. JLR to J. Bertrand, July 10, 1840.
    U. J. Bertrand to JLR, July 13, 1840.
    V. JLR to Joseph M. Kennedy, June 22, 1840.
    W. JLR to Robert M. Patterson, June 8, 1840.
13. July 18, 1840. JLR to Levi Woodbury.
14. July 28, 1840. Robert M. Patterson to Levi Woodbury.
15. July 29, 1840. Robert M. Patterson to Levi Woodbury.
16. April 8, 1841. JLR to Thomas Ewing.
17. April 29, 1841. Silas Reed to Thomas Ewing.
18. May 21, 1841. JLR to Joseph M. Kennedy.
19. November 6, 1841. JLR to John Tyler.
20. December 4, 1848. Robert J. Walker to JLR.
21. December 4, 1848. Robert J. Walker to Joseph M. Kennedy.
22. George Dunlap to Jefferson Davis. (Telegram).

II. Used in Text

1. July 17, 1840. Edward Hall Barton to Robert M. Patterson.
2. June 24, 1840. Levi Woodbury to JLR.
3. March 31, 1849. JLR to William M. Meredith.
4. March 29, 1849. Gustavus A. Nott to William M. Meredith.

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Volume 13 November 16, 1977

Number 3

PRELIMINARY SURVEY OF
MODERN MARINE ENVIRONMENTS
OF SAN ANDRES ISLAND, COLOMBIA
M. JOHN KOCURKO p. 111

PLIOCENE *VOORTHUYSENIELLA* (PROBLEMATICA)
FROM THE TEXAS CONTINENTAL SHELF p. 135

and

COMMENTS ON THE GENUS
VIRGULINELLA CUSHMAN, 1932
(FORAMINIFERIDA)
DREW HAMAN p. 140

Number 4

CARDIIDAE (MOLLUSCA: BIVALVIA) FROM THE CHIPOLA FORMATION,
CALHOUN COUNTY, FLORIDA p. 143

and

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION—XXI
A NEW SPECIES OF THE GENUS *LOPHA* (MOLLUSCA:BIVALVIA)
HAROLD E. VOKES p. 190

A SECOND WESTERN ATLANTIC SPECIES OF
VITULARIA (MOLLUSCA:GASTROPODA) p. 192

and

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION—XXII
ON THE OCCURRENCE OF *DOLICHOLATIRUS* (MOLLUSCA:GASTROPODA)
EMILY H. VOKES p. 195

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PRELIMINARY SURVEY OF MODERN MARINE ENVIRONMENTS OF SAN ANDRES ISLAND, COLOMBIA

M. JOHN KOCURKO
TULANE UNIVERSITY

CONTENTS

Page

I. ABSTRACT 111
II. INTRODUCTION 112
III. LEEWARD ENVIRONMENTS 112
IV. WINDWARD ENVIRONMENTS 114
V. CARBONATE MINERALOGY 126
VI. SUMMARY AND CONCLUSIONS 128
VII. ACKNOWLEDGMENTS 133
VIII. LITERATURE CITED 133

ILLUSTRATIONS

FIGURE 1 112
FIGURE 2 113
FIGURE 3 115
FIGURE 4 116
FIGURE 5 117
FIGURE 6 119
FIGURE 7 120
FIGURE 8 121
FIGURE 9 123
FIGURE 10 125
FIGURE 11 127
FIGURE 12 129
FIGURE 13 130
FIGURE 14 131
FIGURE 15 132
FIGURE 16 132
FIGURE 17 133

I. ABSTRACT

The modern reef complex of San Andres Island, Colombia, can be divided into five major depositional environments on the basis of sediment type and biota. These are: fore-reef, reef crest, back-reef platform, lagoon, and near-shore. Dominant organisms of the reef crest are *Millepora complanata* (hydrozoan), *Palythoa mammillosa* (zoantharian), and calcareous algae. Windward, or the reef-complex environments, are characterized by abundant zoantharian corals, and leeward environments are dominated by alcyonarians.

Modern subtidal sediments from the San Andres area average 70% aragonite and 30% high Mg calcite with a maximum of 20 mole % $MgCO_3$. High concentrations of $MgCO_3$ were found only in sediments from the

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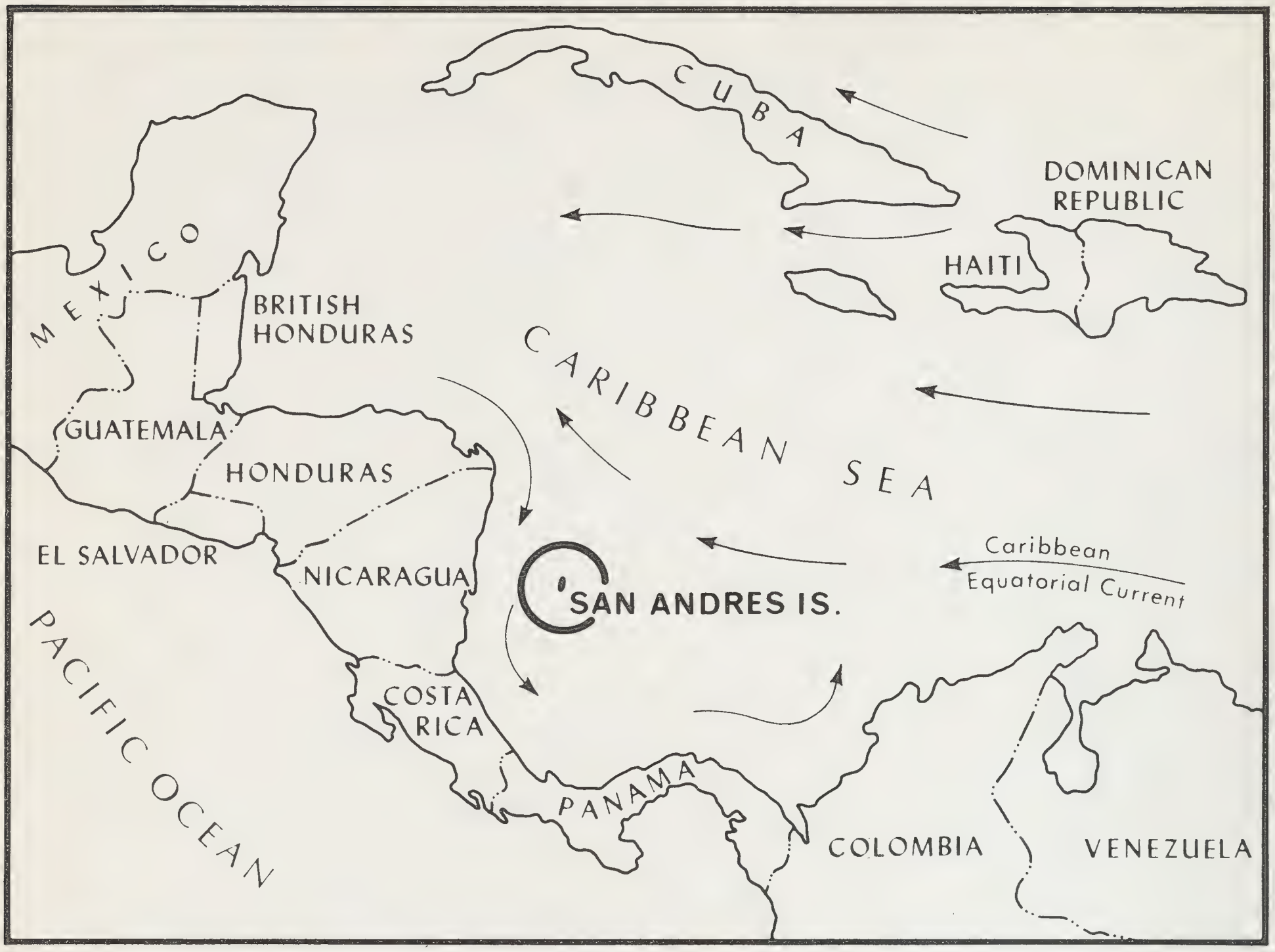


Fig. 1 — General index map of the Caribbean Sea.

reef crest and near-shore (turtle grass) environments and are attributed to coralline algae.

II. INTRODUCTION

San Andres, a Colombian possession, is a small island located approximately 200 km off the Caribbean coast of Nicaragua (Fig. 1). The island, along with several well-developed coralline banks, is situated at the eastern edge of the Nicaraguan Rise. Within a few kilometers of the island, water depths exceed 1800 m, thereby isolating the island from nearby land bodies.

San Andres is approximately 3 km wide and 13 km long and has a maximum elevation of 103 m. The island receives approximately 180 cm of rain annually and has a mean temperature of 27°C. Prevailing winds are from the east and northeast. A barrier reef exists along the east side of the island, whereas the leeward side has no evidence of barrier reef growth but does support a significant coral population.

The purpose of this investigation is to establish the characteristics useful in identifying depositional environments in the island area. These characteristics are based on sediment type and typical bottom biota.

III. LEEWARD ENVIRONMENTS

A distinct faunal zonation can be described from the leeward area (Fig. 2). For convenience, the following descriptive terminology has been applied: Shore zone (Zone 1), upper platform (Zone 2), cliff-and-cave (Zone 3) and lower platform (Zone 4).

Shore Zone

Zone 1 (Fig. 3), or the shore zone, in most places consists of a small cliff or ledge and the surf zone (Figs. 3-1, 3-2). Water depths range from 0 (spray zone) to 2 m. This environment is subjected to pounding

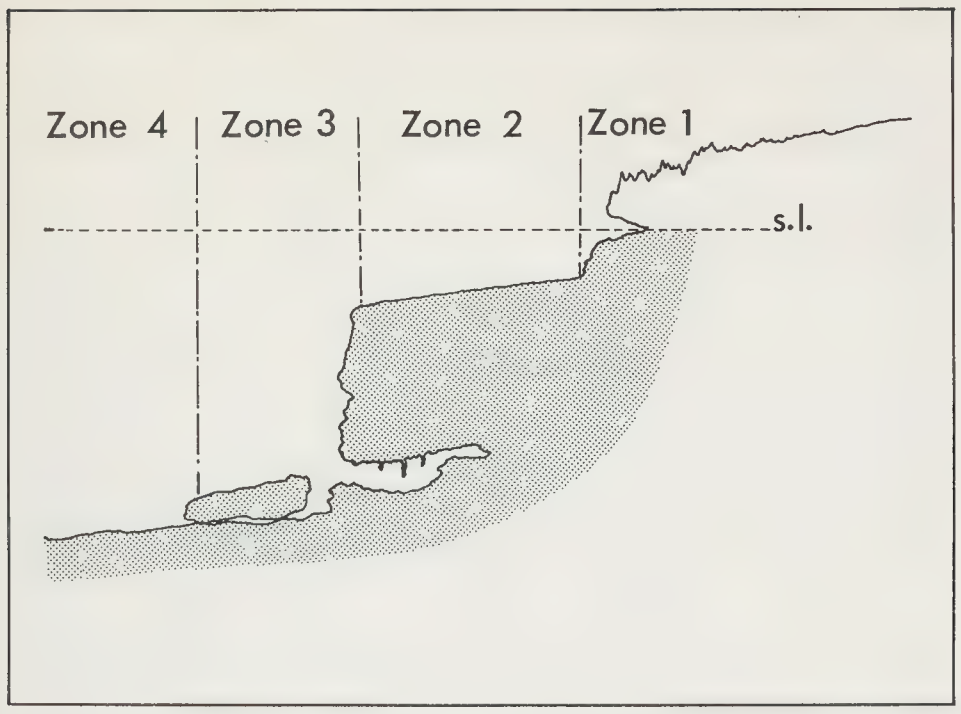


Fig. 2 – Diagrammatic zonation of the leeward side of San Andres Island.

surf or quiet water depending on the season. Zone 1 is dominated by crustose coralline algae (Fig. 3-8). These algae account for the accretion of considerable carbonate material along the shore line, where small ledges, as much as 1 m thick, have been accreted to the cliff face. In addition to algae, encrusting zoanthid anemones (Fig. 3-6) and pelecypods contribute to the accumulation and binding of carbonate material in this zone.

A distinct wave-cut notch, corresponding to present mean sea level can by observed along the leeward side of the island. In addition to wave action, destruction of the carbonate ledges occurs through the action of organisms such as polychaete worms, boring sponges, and the echinoid *Echinometra lucunter* (Fig. 3-4). Zone 1 is characterized also by other organisms including chitons (Fig. 3-7), gastropods, other echinoids (Figs. 3-3, 3-5), encrusting sponges, and small colonies of encrusting zoantharian corals.

Upper Platform

Zone 2, or upper platform (Fig. 4), is a narrow shelf ranging from 2 to 5 m in depth and from several meters to approximately one-half kilometer in width. The bottom slopes gently seaward and is characterized by a hard, limestone substrate with little or no sediment cover. The faunal assemblage in this zone is dominated by alcyonarians and large sponges. Extensive gardens of alcyonarians have developed on the firm substrate and nineteen species were identified from this environment. In addition to alcyonarians, large vase sponges are common and reach heights of almost 2 m with diameters of at least 75 cm. Upon death and decay many of the alcyonarians and sponges contribute calcareous and siliceous spicules to sediments of the surrounding area. Alcyonarian gardens provide protection for numerous mollusks *Cyphoma* and *Pteria* and echinoderms. Many large basket-starfish *(Astrophyton)* were collected from the branches of the sea whip *Pseudopterogorgia.* Zone 2 is also chacterized by small colonies of zoantharian corals.

Cliff-and-Cave Zone

Zone 3, or the cliff-and-cave zone, is characterized by a dominant zoantharian coral growth (Figs. 5 and 6). Most of the organisms are restricted to, or very near to, submarine cliffs. The cliffs form a stable substrate for coral growth, affort protection for colonies, and probably aid in the entrapment of nutrients. Tops of most major cliffs are nearly vertical with many cave openings and small ledges. Bases of cliffs are characterized by a distinct break in slope at a depth of approximately 20 m.

Colonies of zoantharian corals are common throughout Zone 3 and many are attached beneath ledges, in caves, and to the vertical faces of the cliffs. The greatest accumulation of coralline material appears to be at the base of the cliffs. Here large massive colonies (in excess of 1 m in diameter) of faviidaean corals are common.

The caves in Zone 3 support a community of rather rare organisms unique to the environment. There are unusual colonies of *Antipathes* ("Black Coral"), delicate bryozoa, *Stylaster* (colonial hydrozoan), and many types of sponges (Fig. 6). Most of the caves appear to be ancient karst features, which probably developed during Pleistocene low sea level stands. Many submarine caves were found to have fresh water mixing with sea water, indicating subterranean connections with the main island. Large fractures, the result of slumping, can also be traced through the area.

Lower Platform

Zone 4, the lower platform, is the deepest environment investigated. It is characterized by fine-grained, carbonate sediments containing 2 to 5%, by weight, non-carbonate material. Non-carbonate grains consist of hematite, magnetite, marcasite, zircon, volcanic glass, siliceous sponge spicules, and radiolarians. The faunal assemblage is dominated by burrowing organisms, such as worms and crustaceans, with scattered patches of alcyonarians. Zone 4 appears to be terminated seaward by a second set of submarine cliffs, which have been observed only on aerial photographs.

IV. WINDWARD ENVIRONMENTS

The windward (east and northeast) side of San Andres is characterized by the development of a reef complex with the following five distinct ecologic zones (Fig. 7): 1) Shore (the beach and near-shore area), 2) back-reef lagoon (with barren sand and patch reefs), 3) back-reef platform (with sand and coralline rubble), 4) reef crest, 5) fore-reef. This zonation agrees favorably with zones described by Geister (1973).

Shore Zone

The shore zone can be divided into two basic environments: 1) the beach/surf zone, and 2) the near-shore area. Sediments of the beach are medium to coarse-grained and composed almost entirely of carbonate shell fragments. Non-carbonate residue of beach material is usually less than 1%, by weight, and consists of siliceous sponge spicules and organic contamination. In several areas, such as Johnny Cay (Fig. 8-1) and parts of the beach south of the town of San Luis (Fig. 8-2), beach sands have been cemented to form beachrock (Fig. 8-3). These beachrock deposits are typically 1 m thick and 5 to 8 m wide, dip seaward at 3° to 5°, and consist predominantly of coarse-grained carbonate sand (95%). Coral fragments, foraminifers, echinoid, pelecypod, and gastropod fragments, and unidentifiable grains are the most common grain types (Fig. 8-4). In addition to sand particles, large fragments of the gastropod *Strombus gigas* are abundant. Cementation is accomplished by precipitation of aragonite around individual grains, as can be observed in thin sections from most beachrock samples (Figs. 8-4, 8-5). Similar beachrock formation has been described by Ginsburg (1953), Friedman (1968), and Gavish and Friedman (1969). Stratification in many of the samples (Fig. 8-3) is caused by differential cementation. The first few centimeters of the beachrock, although well cemented by aragonite, are very porous. Beachrock areas are characterized by numerous living organisms that do not inhabit areas of uncemented beach sands. Apparently the firm substrate yields more protection. The dominant organisms are gastropods *(Nerita* spp., *Cittarium pica,* and *Purpura patula),* the echinoid *Echinometra lucunter,* and polychaete worms.

Unconsolidated sediment samples, collected near beachrock deposits, show the same general textural parameters as rock counterparts. Sieve analyses of the sands

---

Fig. 3 – Physiography and typical biota of shore zone (Zone 1).

1. Small submarine cliff at the present shore line. Note abundant echinoids of the genus *Diadema* (photo courtesy of Dr. Frank Barnwell).
2. Wave-cut notch at present sea level, on the leeward side of San Andres Island.
3. *Eucidaris tribuloides.*
4. *Echinometra lucunter.*
5. *Diadema antillarum.*
6. *Palythoa* sp.
7. *Ischnochiton* sp.
8. Algal encrustation on a broken bottle.

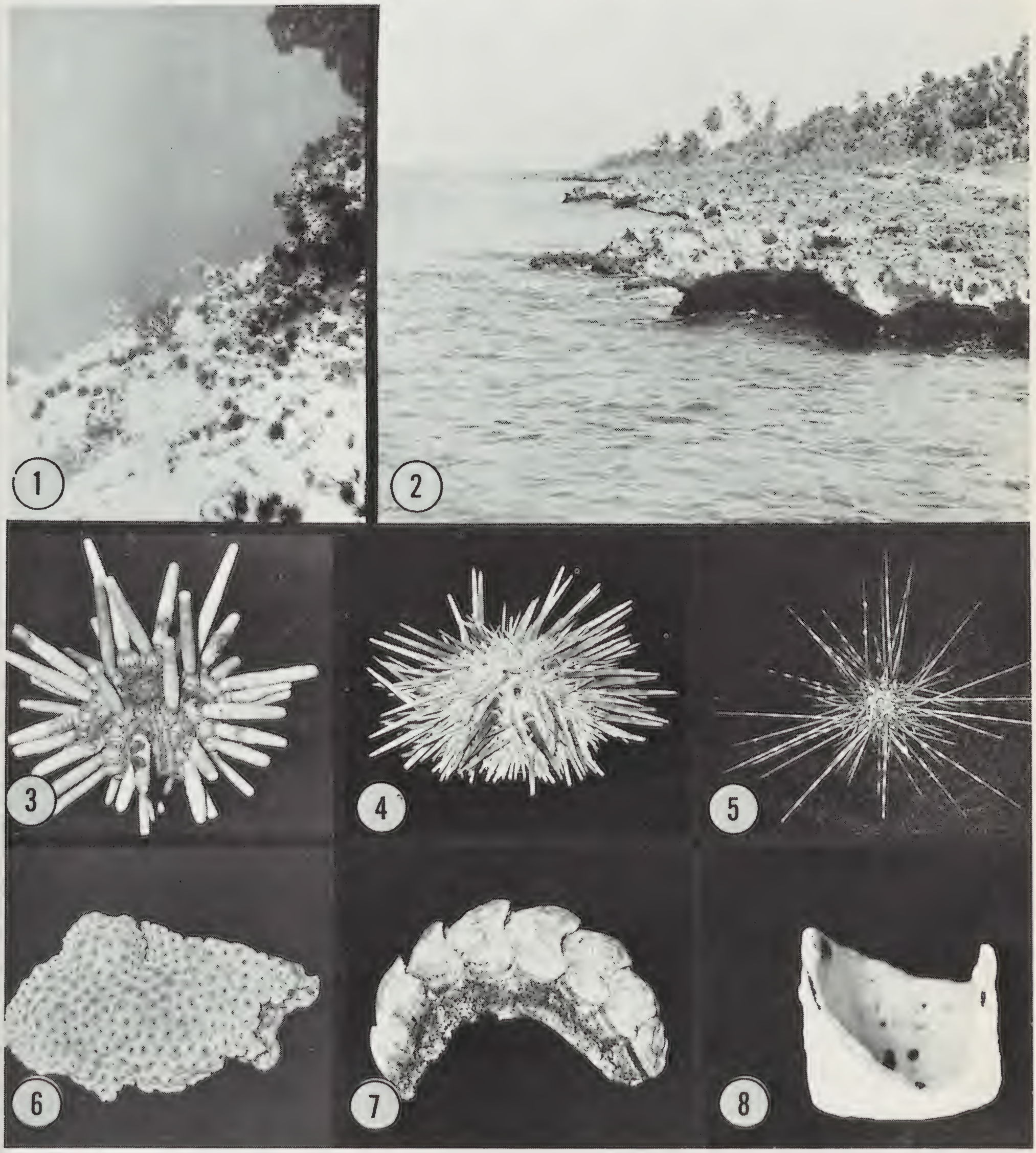


FIGURE 3

Fig. 4 – Typical bottom community of the upper platform (Zone 2).

indicate 90% of the sand material is coarse-grained (greater than 0.50 mm in diameter). Typically, the beach/surf zone is sparsely inhabited and can be characterized by fragments of large gastropod and pelecypod shells, coral debris, and limestone pebbles eroded from the island.

The second environment of the shore zone is the near-shore, or turtle grass area, which is immediately seaward of the surf zone. In this zone, water depth is less than 4 m. The bottom community and sediment in this area are diverse (Fig. 9-1). Most of the bottom material is covered by *Thalassia testudinum* (turtle grass) (Fig. 9-2) and coralline algae (Fig. 9-3), which act as effective sediment binders. In addition, the green algae *Halimeda, Udotea, Penicillus* and *Rhipocephalus* are also important sediment contributors and binders. This relationship has been reported by several investigators (Ginsburg, 1956; Scoffin, 1970; and Till, 1970). In addition to algae, the turtle grass area also has a large population of small zoantharian corals. Corals of particular importance as zone indicators are: *Diploria*

Fig. 5 – Typical biota of cliff-and-cave zone (Zone 3).

1 and 4. *Mussa angulosa.*

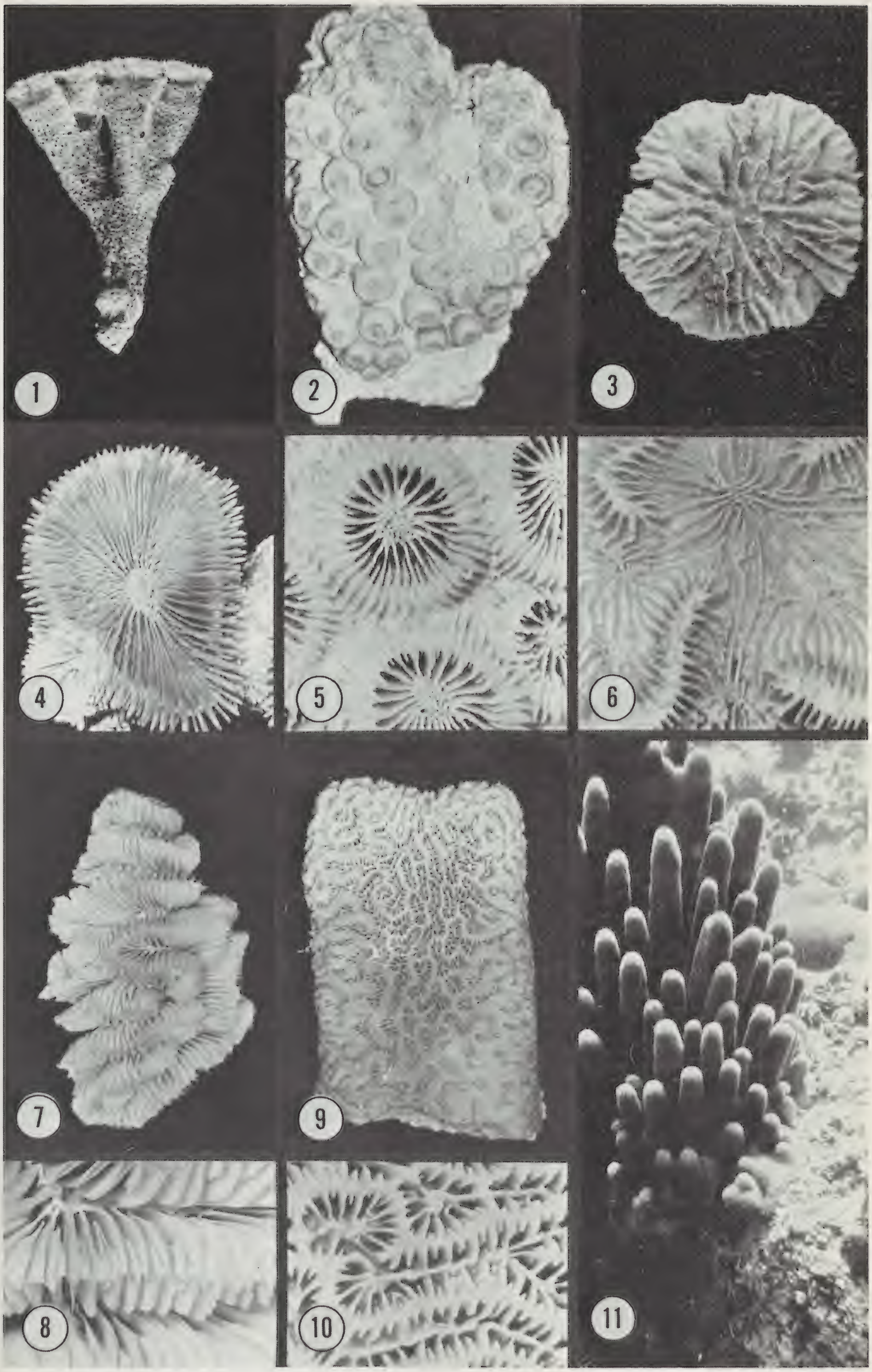
2 and 5. *Montastrea cavernosa.*

3 and 6. *Isophyllia sinuosa.*

7 and 8. *Meandrina meandrites.*

9 and 10. *Dendrogyra cylindrus.*

11. Large colony of *D. cylindrus* approximately 1 m in height (photo courtesy of Dr. Frank Barnwell).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clivosa, Manicina areolata (Fig. 9-6), *Porites porites* (Fig. 9-4), *Porites asteroides* (Fig. 9-7), and *Siderastrea radians.* Another zone indicator in the turtle grass area is the echinoid *Lytechinus varigatus* (Fig. 9-5), which is seldom found living outside the turtle grass area or at depths greater than 4 m below sea level.

In addition to grassy bottoms in the shore zone, there are areas that are covered with coralline rubble. The bottom material appears to be derived from dead reefs of probable Pleistocene age and is particularly evident along the northeastern shore line of the island.

Back-Reef Lagoon

The back-reef lagoon (Fig. 10-1) is a complex area made up of two principal environments, barren sand bottom and patch reef. The periphery of the lagoonal area is characterized by a distinct break in slope at a depth of approximately 5 m where the bottom becomes flat and featureless. The lagoonal area is almost completely enclosed by shallow platforms, where there is little sediment cover and eroded limestone with fossil corals is commonly exposed. Water depths at the lagoonal periphery correspond to depths at the tops of submarine cliffs on the leeward side of the island (approximately 5 m). Based on the apparent terracing, it is probable that the bathymetry of the lagoon was modified during a Pleistocene low sea level stand. The bottom of the lagoon is flat and the biota is characterized by small, scattered patches of *Halimeda,* foraminifers, the gastropod *Strombus gigas,* scaphopods, burrowing worms and crustaceans, the pelecypod *Pinna* sp., and irregular echinoids. Coral growth is seemingly absent.

Lagoonal sediment is poorly sorted, with an abundance of fine material. Almost 60% of the sand is less than 0.149 mm in diameter. Orbitoid foraminifers constitute up to 35% of lagoonal sand grains. Non-carbonate residues consist of radiolarian remains and sponge spicules. Based on X-ray analysis, the samples are approximately 70% aragonite and 30% high-magnesian calcite, with 16 mole % $MgCO_3$ in the calcite fraction.

Scattered throughout the lagoon are small patch reefs (Fig. 10-2), most of which are round to oval in plan view, dome-shaped, and 10 to 30 m in diameter. Water depth over the top of the patch reefs ranges from less than 1 m to nearly 10 m.

Typically, the patch reef community is dominated by one of the three following organisms: alcyonarians, *Montastrea annularis* (Fig. 10-6), or *Acropora palmata* (Fig. 10-5). *Montastrea annularis* appears to dominate the deeper patch reefs (deeper than 7 to 10 m) (Fig. 10-4), whereas *A. palmata* prefers shallower environments (Fig. 10-3). Alcyonarians are present in both settings, but apparently prefer intermediate depths of 3 to 7 m. Other organisms occurring in the patch reef environment include: encrusting algae, *Millepora* sp., numerous small zoantharian corals, gastropods, sponges, and crustaceans.

Back-Reef Platform

Back-reef platforms, surrounding the lagoonal area, represent Pleistocene terraces.

Fig. 6 – Typical biota of cliff-and-cave zone (Zone 3) (continued).

1 and 4. *Colpophyllia* sp.

2 and 5. *Diploria strigosa.*

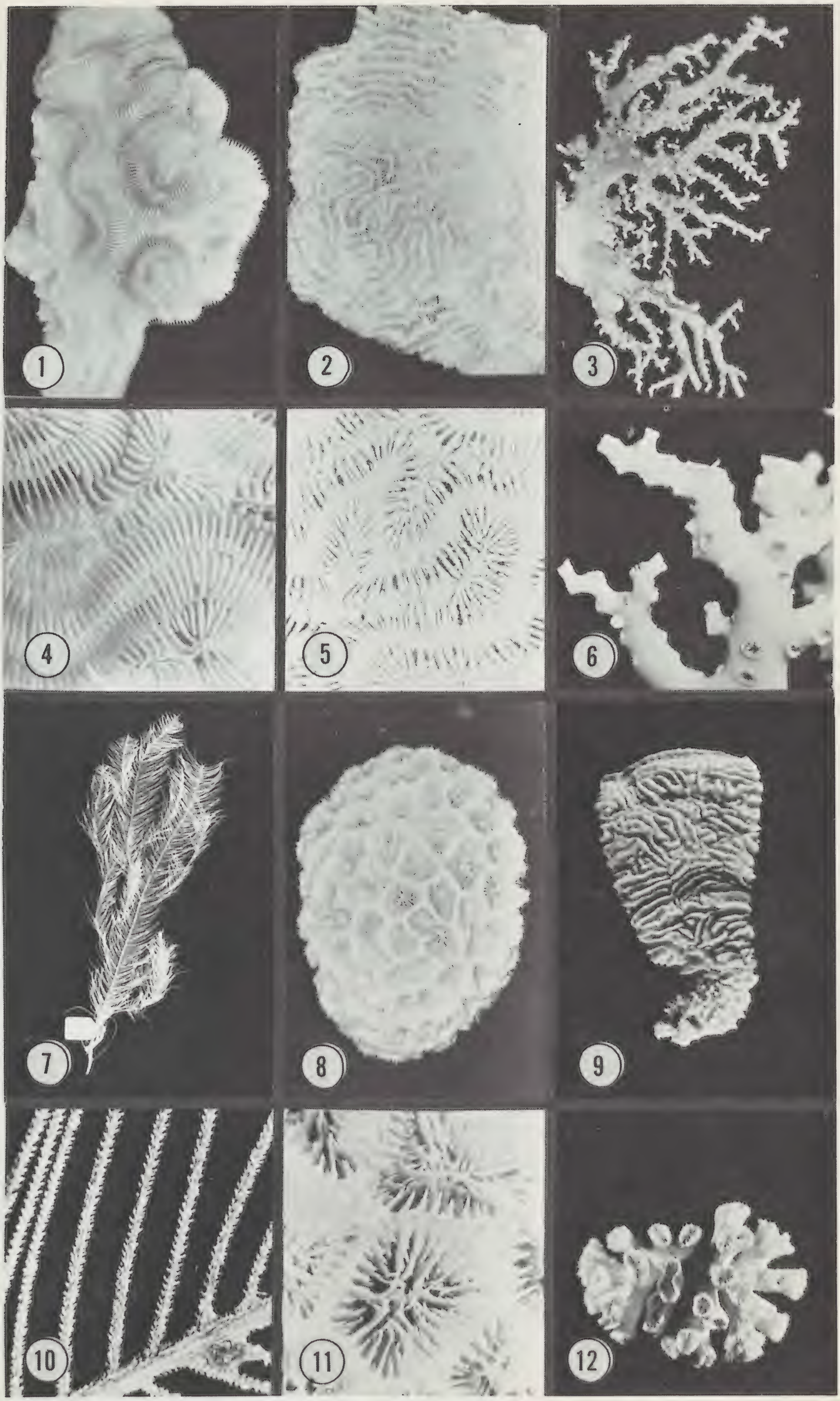
3 and 6. *Stylaster* sp. (cave fauna).

7 and 10. *Antipathes* sp. (cave fauna).

8 and 11. *Isophyllastrea rigida.*

9. Porifera (cave fauna).

12. *Eusmilia fastigiata.*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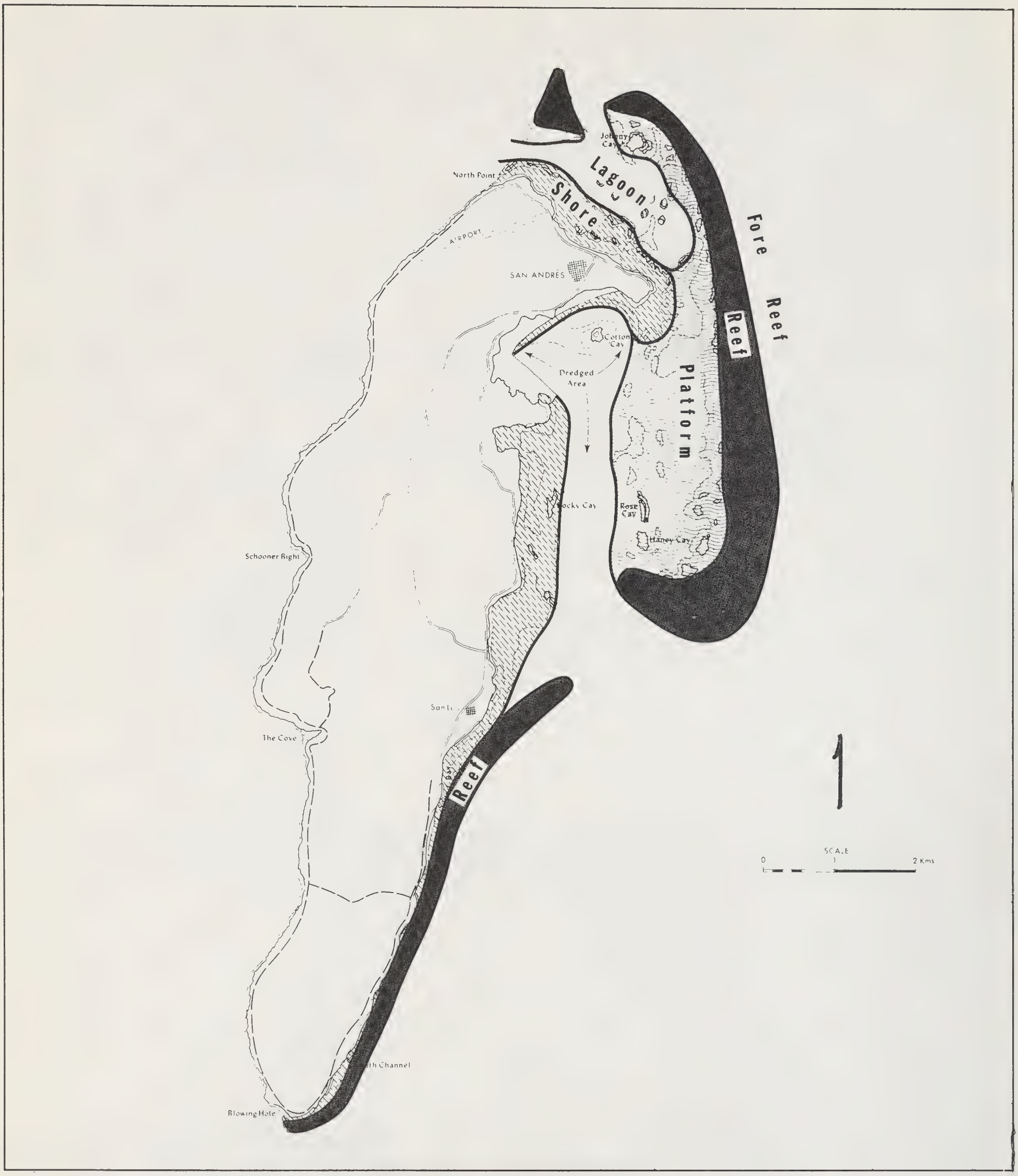

Fig. 7 – Depositional environments of the windward side of San Andres Island.

Fig. 8 – Modern beachrock deposits, San Andres Island.

1. Aerial photograph of Johnny Cay. Note crescent shape deposits of beachrock on the windward side. Arrow indicates direction of prevailing winds.
2. Beachrock deposit along the beach, south of San Luis.
3. Polished block of beachrock material (sample 29-F/R-61). Note stratification and primary porosity. Arrow indicates up direction.
4. Photomicrograph of sample 29-F/R-61. Arrow indicates location of photomicrograph 5.
5. Aragonite cement of sample 29-F/R-61.

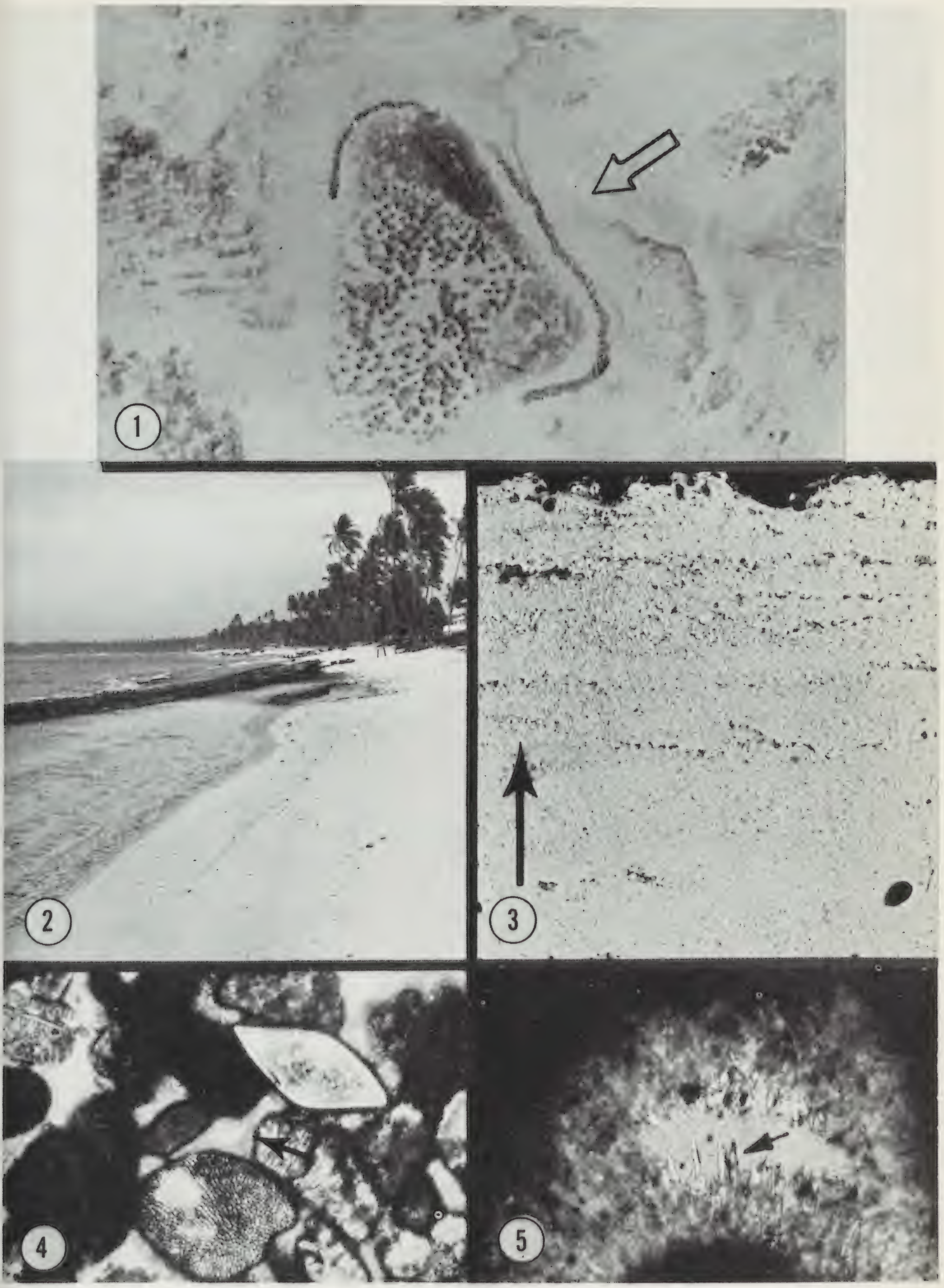

FIGURE 8

Sediment cover is typically 3 to 5 cm thick and in a few places exceeds 25 cm. The limestone platforms, cut by wave action, are typically flat and featureless with a water depth of approximately 2 m. Leeward sides of platforms are commonly marked by a distinct slope break at the edge of the back-reef lagoon. The windward side also is characterized by a slope change and the development of a barrier reef.

Three distinct environments are found within the platform area: barren sand, rubble deposits, and small patch reefs.

Platform areas are typically covered by a thin veneer of relatively barren, rippled carbonate sand (Fig. 11-1). Bottom communities are restricted to gastropods (*Strombus gigas, Vasum muricatum*, and *Oliva* sp.), the irregular echinoid *Clypeaster subdepressus* (Fig. 11-4), and burrowing crustaceans.

Sediment from the platform area is poorly sorted, with approximately 85% of the sample being coarser than 0.25 mm. Dominant constituent grains are foraminifers (27%), algae (20%), and coral fragments (15%).

Rubble deposits (Figs. 11-2, 11-3), on the back-reef platform, are very significant as environmental indicators in the San Andres area. Many rubble deposits have been reported as fore-reef accumulations associated with reefs (Ginsburg, 1964). However, Kornicker and Boyd (1962) reported rubble deposits from the back-reef lagoon area of the Alacran reef in Mexico. Apparently location of the rubble zone is a function of both reef configuration and wave direction. The rubble consists of large fragments of eroded coral debris (Fig. 11-3). Specimens average 10 cm in length and 3 to 5 cm in width. Fragments of *Acropora cervicornis, A. palmata, Porites porites,* and *Millepora* sp. have been identified. Of these organisms, *A. palmata* and *P. porites* are the dominant constituents. Fauna of rubble deposits is commonly restricted to crustaceans, polychaete worms, and mollusks. Living coral is absent. Most of the rubble material is coated by encrusting red algae, which serves as a cementing agent in many locations. Only 4% of the material from the rubble zone is less than 0.25 mm in diameter. The remaining 96% consists of coarse-grained sand with 35% of grains having diameters greater than 2.0 mm. The crustose coralline algae comprise almost 15% of the constituent grains and *Halimeda* contributes approximately 20%. Non-carbonate residue samples consist primarily of sponge spicules and radiolarian remains.

Scattered throughout the back-reef platform zone are small, isolated patch reefs (Fig. 12-1). These reefs are commonly less than 20 m in diameter and no more than 2 m high (Figs. 12-2, 12-3). Three organisms (Figs. 12-4, 12-5, 12-6) dominate the patch reefs and represent the principal frame builders in this zone: *Acropora palmata, Porites porites,* and *Diploria strigosa*. Numerous minor zoantharian corals exist here also, but are unimportant as frame builders. In addition to corals, the following organisms can be found within the patch reef frame: *Diadema antillarum* and *Eucidaris tribuloides* (echinoids), sea anemones, gastropods (*Astraea* sp. and *Conus* sp.), *Millepora* sp., crustaceans, and sponges.

Fig. 9 – Typical biota of the near shore (turtle grass) zone.

1. General configuration of the bottom in turtle grass areas. A Trigger Fish is in the foreground (photo courtesy of Dr. Frank Barnwell).
2. Close-up of bottom material (courtesy of Union Oil Company of California).
3. Coralline algae.
4. *Porites porites*
5. *Lytechinus varigatus.*
6. *Manicina areolata.*
7. *Porites astreoides.*

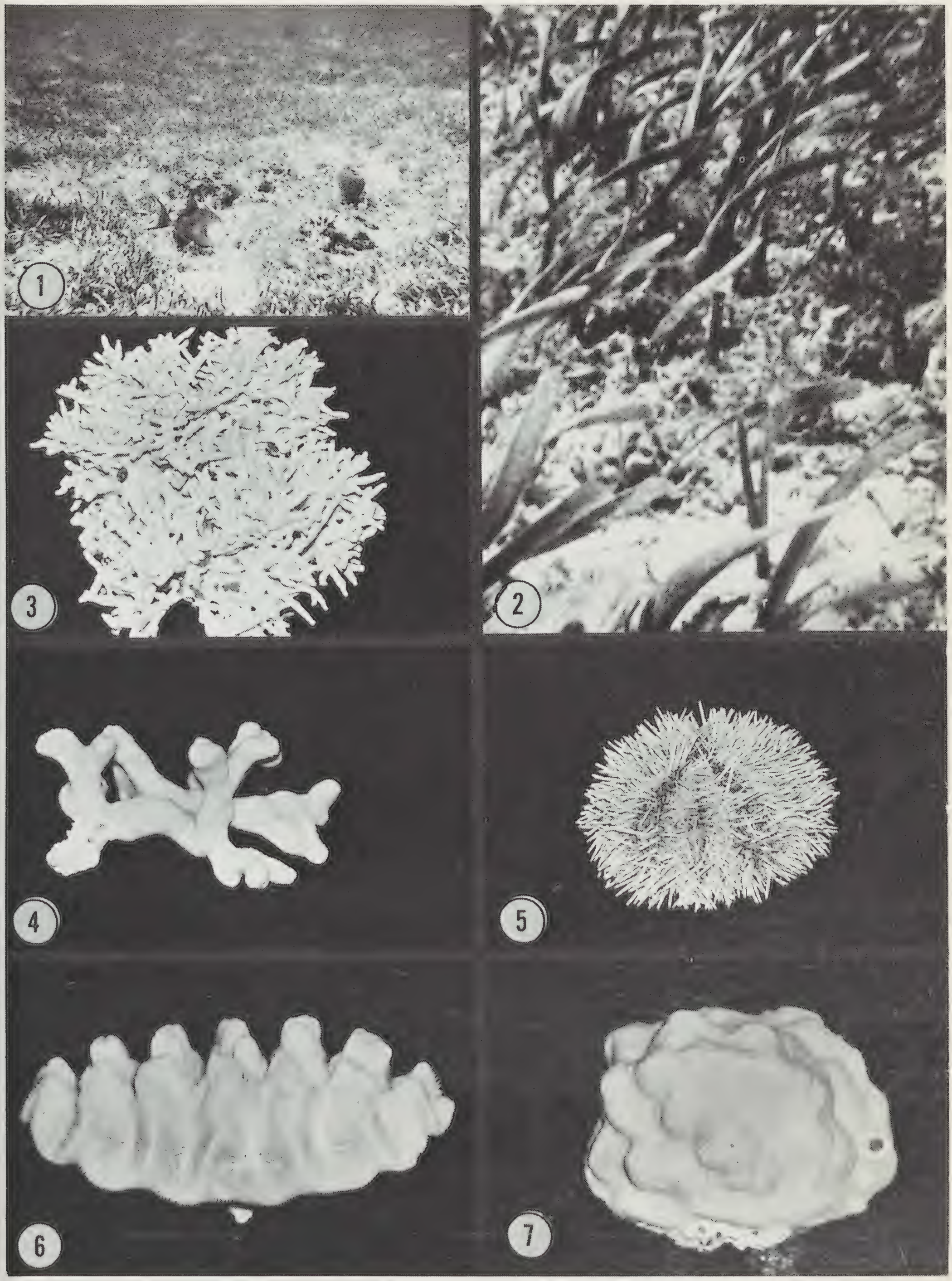

FIGURE 9

Reef Crest

The main reef crest lies along the windward margin of the platform zone. The barrier reef in the San Andres area (Fig. 7) has been subdivided into a northern reef and a southern reef. The reef tract is approximately 15 km long and aligned in a north-south direction. The northern reef is approximately 3 km from shore, whereas the southern reef is less than 300 m from shore. Water depth across the top of the reef is normally less than 30 cm and corals are commonly exposed during spring tides. The immediate back-reef water depth is less than 2 m, whereas the immediate fore-reef water depth ranges from 5 to 10 m.

Two distinct morphological differences exist within the reef crest. The north end of the northern reef is characterized by a gentle slope on the seaward side. The sea bottom is lithified coralline material approximately 5 m thick, in which subsurface passageways are developed. Extensive coral growth has formed a canopy (false bottom), sloping 10° to 15° seaward, throughout this area. The false bottom supports only a sparse community of corals and algae. At the crest of the main reef is a well-developed community of *Millepora complanata* (Figs. 14-2, 14-4), *Palythoa mammillosa* (Fig. 14-3), and encrusting algae. The northern section of the reef tract probably represents the oldest part of the modern reef crest, and growth is apparently now suppressed.

The southern section of the northern reef and the southern reef are, at present, growing rapidly. Large pinnacles of *Millepora* and lime secreting algae form the frame of the reef crest (Fig. 14-1). Openings in the frame are filled by numerous zoantharian corals, gastropods, and alcyonarians. Isolated patches of *Acropora palmata* and *Montastrea annularis* are also present, but they represent seaward patches of coral rather than part of the main reef crest.

The pinnacles of *Millepora* are as much as 10 m high and 3 m in diameter, rising to within a few centimeters of sea level. They are separated by narrow, vertical-walled channels that are less than 1 m wide (Fig. 14-5). These channels form an intricate maze within the reef crest and probably correspond to the caves (passageways) of the northern section of the reef. The channels are characterized by strong, surging currents, which are related to wave action. Rippled sand is common, and most ripples have an amplitude of 10 cm, a wavelength of 45 cm, and are formed perpendicular to the surge direction. Bottoms of channels are commonly filled with well-sorted, coarse-grained carbonate sand. There are no fine materials and 99% of the grains are greater than 0.50 mm in diameter. Dominant constituent grains are coralline fragments (25%), and almost 45% of the grains are unidentifiable. No non-carbonate residue was recovered.

Coralline growth is restricted to the upper portion of the channel walls. The lower 1 m is marked by clean, eroded, coralline limestone. The channels have no apparent orientation. They form meander-like passageways through the reef tract, and open into small "courtyard-like" areas. The "courtyards" are approximately 6 m deep. The bottoms are flat and veneered with sand. They are commonly enclosed by vertical walls of *Millepora* and algae.

Fig. 10 — Back-reef lagoon zone, San Andres Island.

1. Aerial photograph of the northern San Andres area. Arrow indicates patch reef.
2. Aerial photograph of individual patch reefs.
3. Underwater photograph at edge of a patch reef built by *Acropora palmata.*
4. Underwater photograph of patch reef built by *Montastrea annularis.*
5. Individual specimen of *Acropora palmata.*
6. Individual specimen of *Montastrea annularis.*

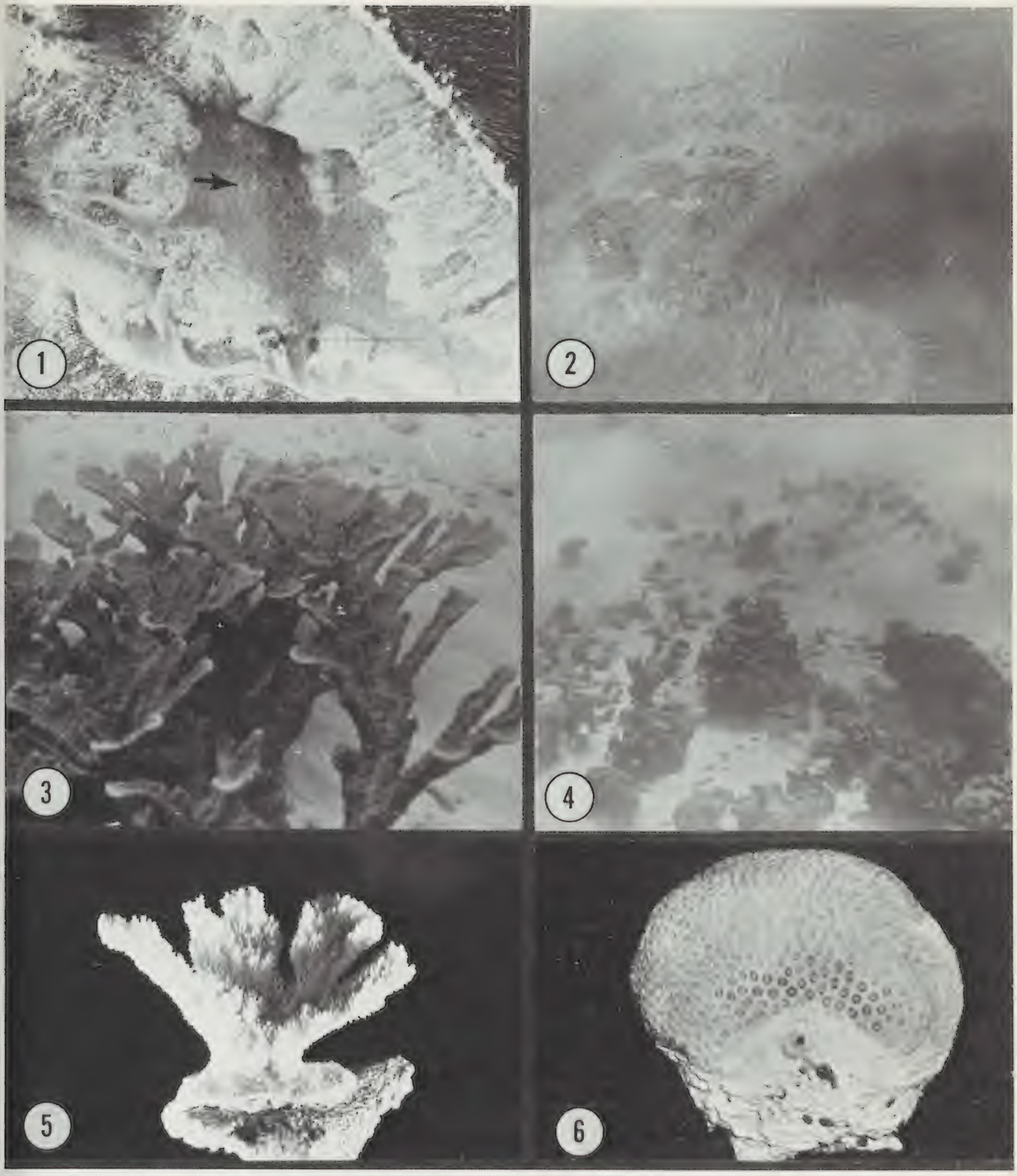

FIGURE 10

The primary frame builder of the San Andres reef crest is *Millepora complanata* (Figs. 14-2, 14-4). However, the reef tract is characterized by numerous zoantharian corals and alcyonarians; 25 species of coral have been identified from this zone. Almost all of the species of coral found on the windward side of the island can be found within the reef crest.

Fore-Reef

The fore-reef zone in the San Andres area is characterized by a hard, coralline limestone bottom, covered by numerous small zoantharian corals and alcyonarians. This zone extends seaward of the reef crest locally for a distance of approximately 5 km and probably represents an eroded terrace of Pleistocene age. The bottom slopes seaward at 2° to 5°, and is somewhat irregular, being modified by long, linear channels, which can be traced seaward from the reef zone. The channels are generally less than 1 m wide at the bottom, with sides that slope at 30° to 40°. The water depth in channels is 10 to 15 m and becomes progressively deeper in the seaward direction. Channels can be observed both from the air and underwater and are probably spur and groove structures similar in design to those described by Shinn (1963) in Florida. The main water currents through this zone at the time of sampling were parallel to the reef crest. None corresponded to the direction of the channels.

Carbonate sediment from the bottoms of the channels is characteristically coarse-grained with 90% of the grains having a diameter greater than 0.50 mm. No non-carbonate residue was recovered from the sample. Fragments of coral (10%), echinoids (10%), and *Halimeda* (12%) are the principal constituent grains. Forty per cent of the grains were unidentifiable.

Due to lack of adequate equipment and heavy seas, no observations were made in the fore-reef zone farther than 3 to 4 km seaward of the main reef crest.

V. CARBONATE MINERALOGY

Marine sediments from the San Andres Island area were analyzed by X-ray diffraction methods and relative percentages of aragonite, high-magnesian calcite, and low-magnesian calcite were determined by methods evaluated by Royse, Wadell and Petersen (1971). Sediment sample sites for the windward side of the island are shown in Figure 13. The sediments were found to have an average composition of 70% aragonite, 30% high magnesian calcite, and 0% low-magnesian calcite. However, beach sands were found to contain as much as 32% low-magnesian calcite, with an average of 10% low-magnesian calcite, 22% high magnesian calcite, and 68% aragonite. Figure 15 depicts the compositional distribution of these sediments. The samples indicated in Figure 15 may be separated into four classes: 1) Subtidal sediments, 2) beach or near-shore sands, 3) beachrock, 4) limestone deposits of late Pleistocene age. Generally, samples consist of the top few inches of lagoonal or near-reef sediments. Beach and near-shore sands are subaerially exposed or contaminated by detrital, low-magnesian calcite derived from older limestones. Beachrock and deposits of late Pleistocene age are in some phase of early diagenesis and are lithi-

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Fig. 11 – Back-reef rubble zone of the modern reef, San Andres Island.

1. Aerial photograph showing the well developed back-reef rubble (R) and sand (S) deposits.

2 and 3. Typical coralline rubble.

4. *Clypeaster subdepressus,* a common echinoid on the sand bottom.

5. *Diadema antillarum,* communities of this echinoid are common on both sand and rubble bottoms.

6. A common echinoid on the sand bottom.

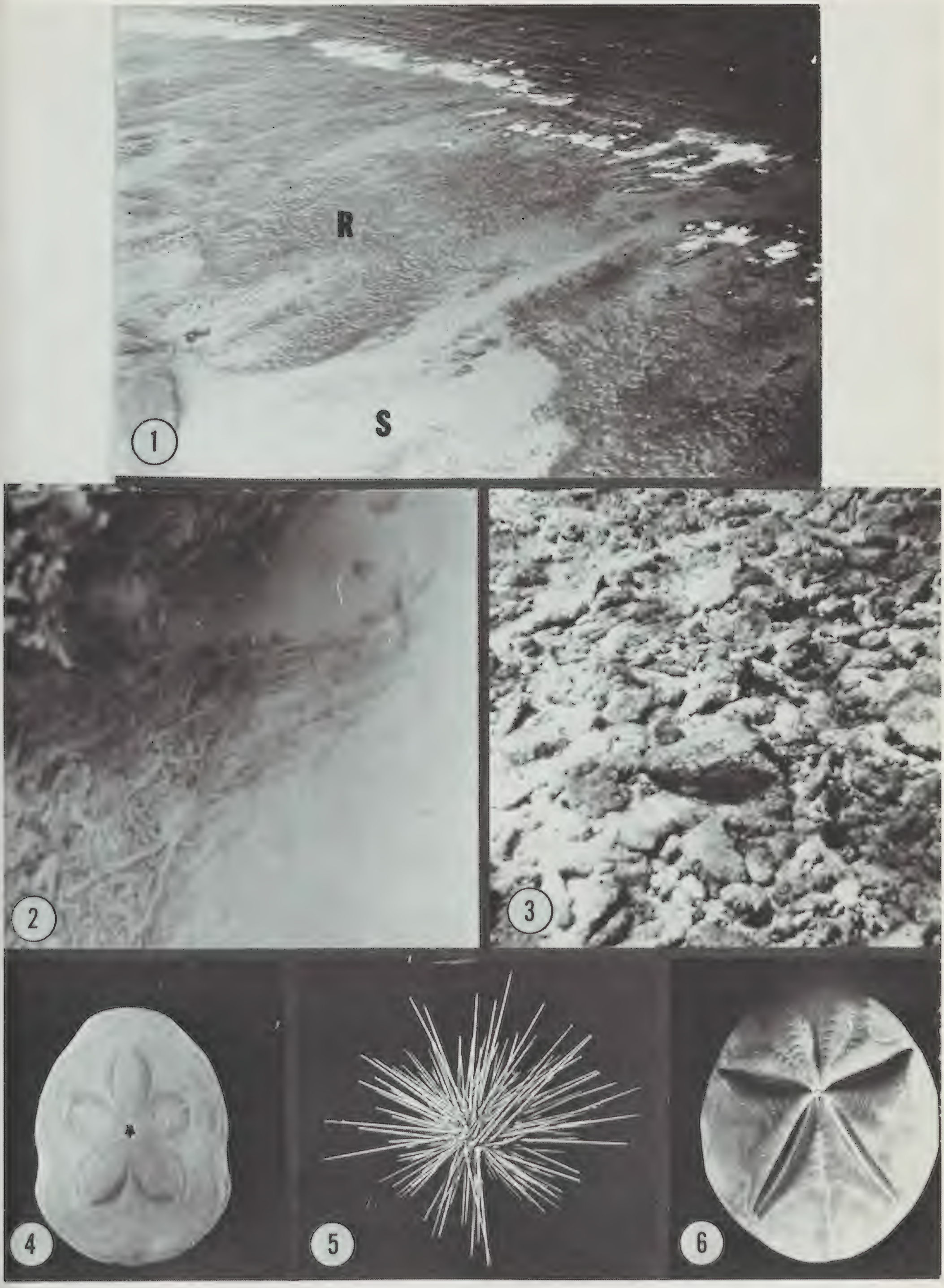

FIGURE 11

fied. As might be expected, the tendency for conversion to low-magnesian calcite is related to age and probable subaerial diagenesis. It should be noted that low-magnesian calcite was found only in the near-shore areas where there is a good possibility of subaerial exposure.

No dolomite was found in any of the sediment samples collected in the San Andres area. However, high-magnesian calcite may contain up to 20 mole % $MgCO_3$ in many areas. Figure 16 depicts the distribution of $MgCO_3$ based on mole % in high-magnesian calcite. It is interesting to note that two anomalous areas exist within the reef complex: the turtle grass zone and the main reef crest. These high concentrations of $MgCO_3$ can probably be explained by the presence of coralline algae and the echinoids *Lytechinus* and *Diadema*. High magnesium concentration is found in the skeletal parts of both forms (up to 43.5 mole % $MgCO_3$). Even though this high per cent is localized, its presence indicates an ability to concentrate magnesium (Schroeder, *et al.*, 1969). According to Schmalz (1965), the red alga *Goniolithon* may contain up to 18 mole % $MgCO_3$ (by X-ray analysis).

VI. SUMMARY AND CONCLUSIONS

The characteristics of the modern environments of San Andres can be summarized best by a comparison of biota, sediment, and bottom physiography. With the data presented, it is then possible to determine particular zone parameters.

The leeward side of the island can be characterized by: 1) well-developed cliffs, caves, and wave-cut notches; 2) encrusting red algal accumulations in the surf zone; 3) accumulation of massive corals at bases of large submarine cliffs; 4) extensive alcyonarian gardens. The leeward side of the island consists of a series of cliffs and terraces eroded by waves during fluctuation of sea levels during Pleistocene time. The modern sediments form a thin veneer, superimposed on old erosional surfaces.

The environments of the windward side of the island can be distinguished on the basis of sediment composition. By comparing samples from traverses noted in Figure 13, it is possible to show relative changes in percentages of constituent grains (Fig. 17). By comparisons of this type, several interesting changes can be observed in the contents of the samples:

1. Large percentages of foraminifers are present in back-reef ecologic zones, and foraminifers decrease in abundance as one approaches and passes the main reef crest.
2. The abundance of coralline algae gradually increases toward the reef crest.
3. As might be expected, coral fragments increase in abundance toward the reef crest, as do echinoid fragments and gastropod remains.
4. The percentage of pelecypod fragments is higher toward the shore and decreases toward the reef crest.
5. Alcyonarian spicules generally decrease toward the reef crest but they are abundant on the leeward side of patch reefs.

Although *Millepora complanata* is the primary frame builder of the reef crest in the San Andres area, it should be pointed out that this relationship is not common. When comparisons are made with other modern reef areas, *Millepora* is typically found to be

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Fig. 12 – Patch reefs of the back-reef platform zone.

1. Oblique aerial photograph of the immediate back-reef platform with small patch reefs. The island is Johnny Cay.
2. Underwater photograph of a patch reef constructed by *Diploria strigosa* and *Acropora palmata* (photo courtesy of Union Oil Company of California).
3. Underwater photograph of *Porites* patch reef.
4. *Acropora palmata.*
5. *Diploria strigosa.*
6. *Porites porites.*

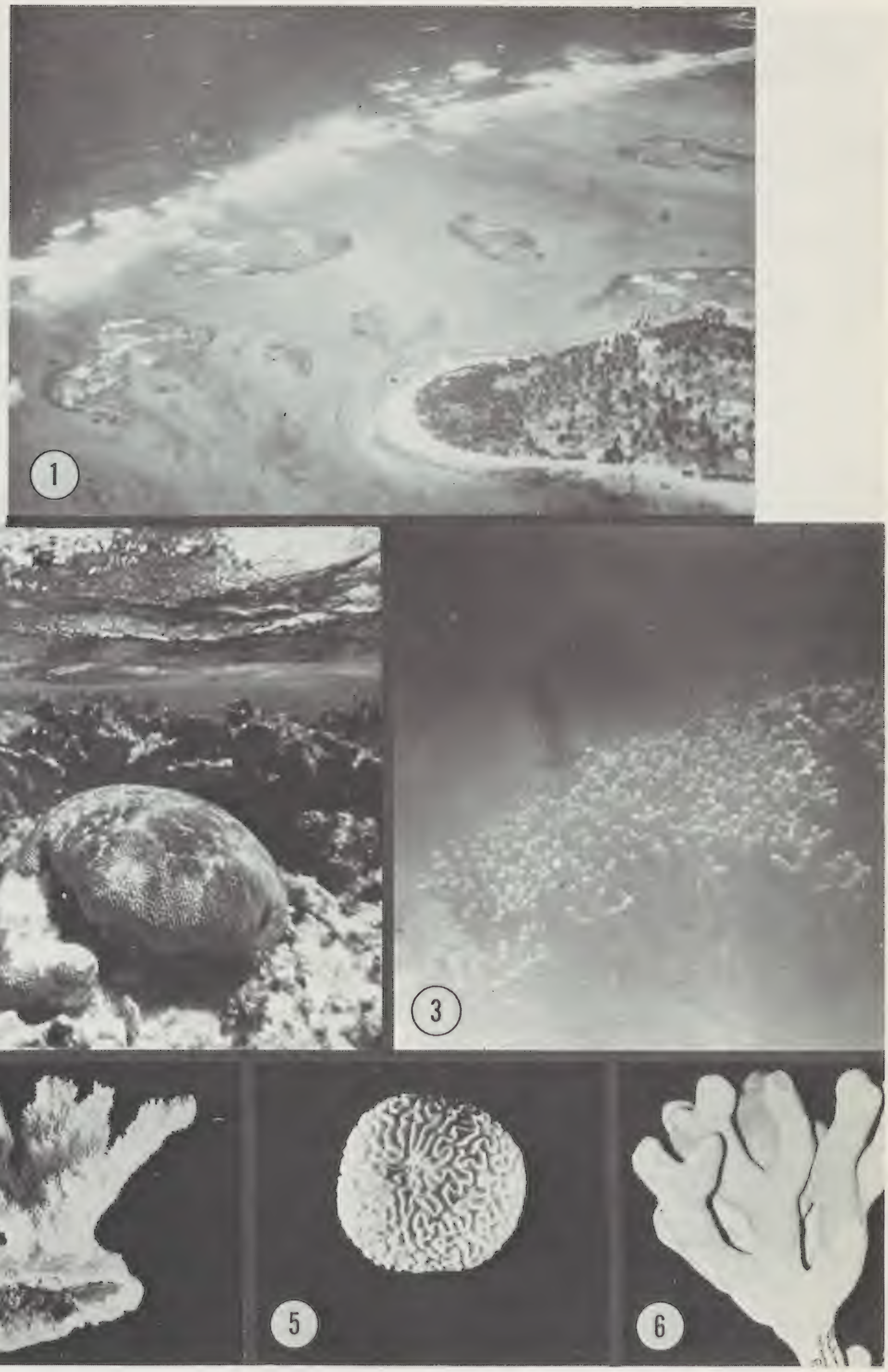


FIGURE 12

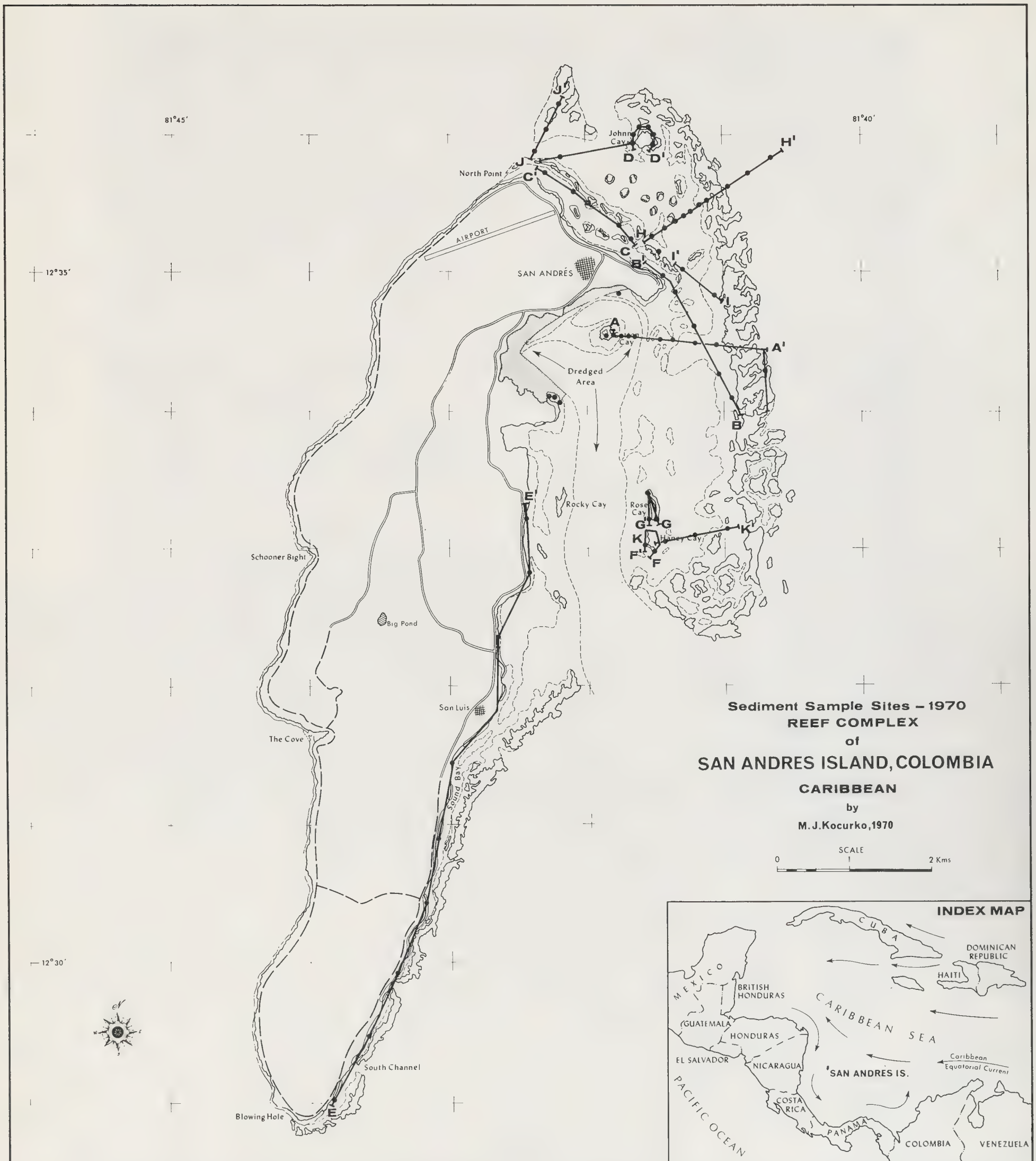


Fig. 13 – Sediment sample sites from the windward side of San Andres Island.

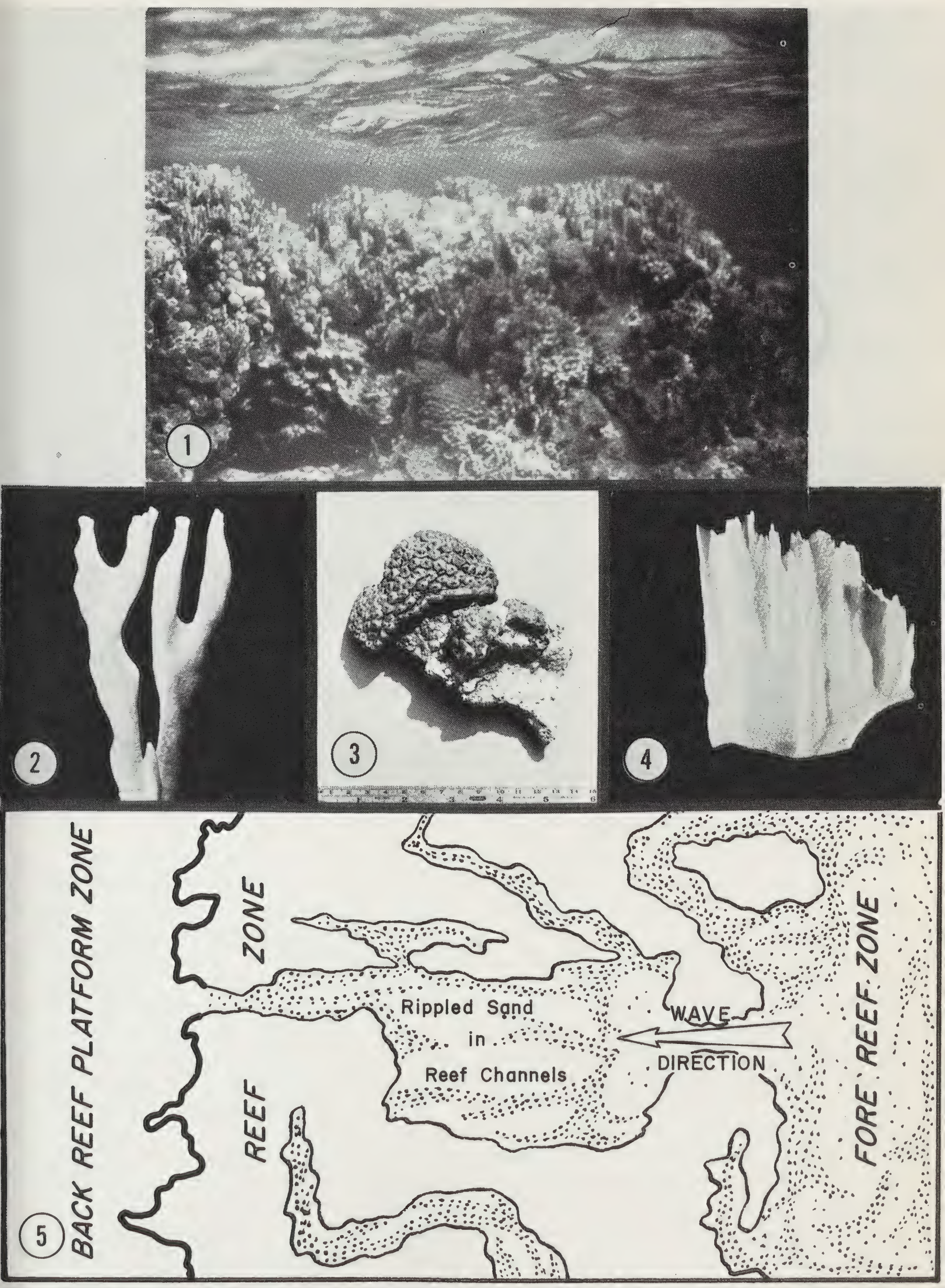
Fig. 14 – Main reef crest, San Andres Island.

1. Underwater photograph of the main reef crest (cross-sectional view). The fore-reef zone is to the right.

2 and 4. *Millepora complanata.*

3. *Palythoa mammillosa.*

5. A diagrammatic map of reef channels.


1
2
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BACK REEF PLATFORM ZONE
REEF ZONE
Rippled Sand in Reef Channels
WAVE DIRECTION
FORE REEF ZONE

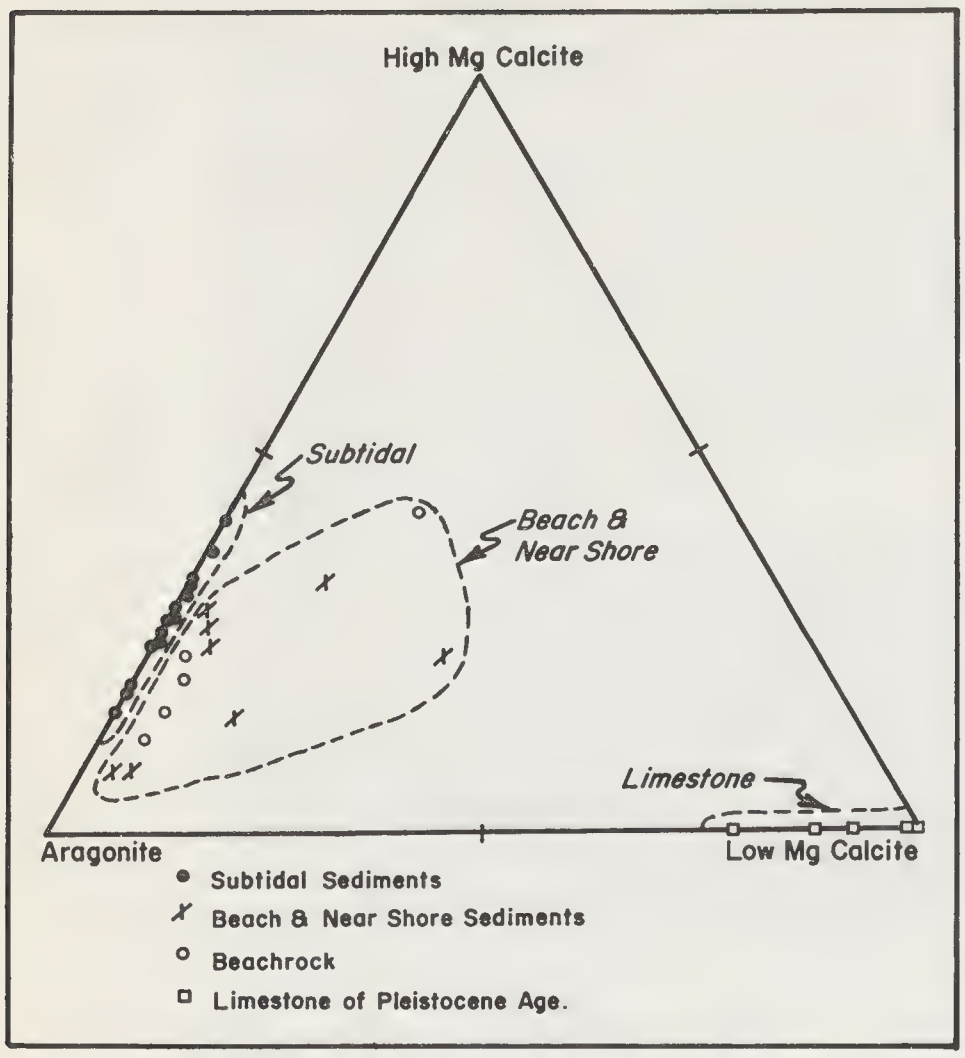

Fig. 15 – Mineralogy distribution of sediment and limestone samples from San Andres Island.

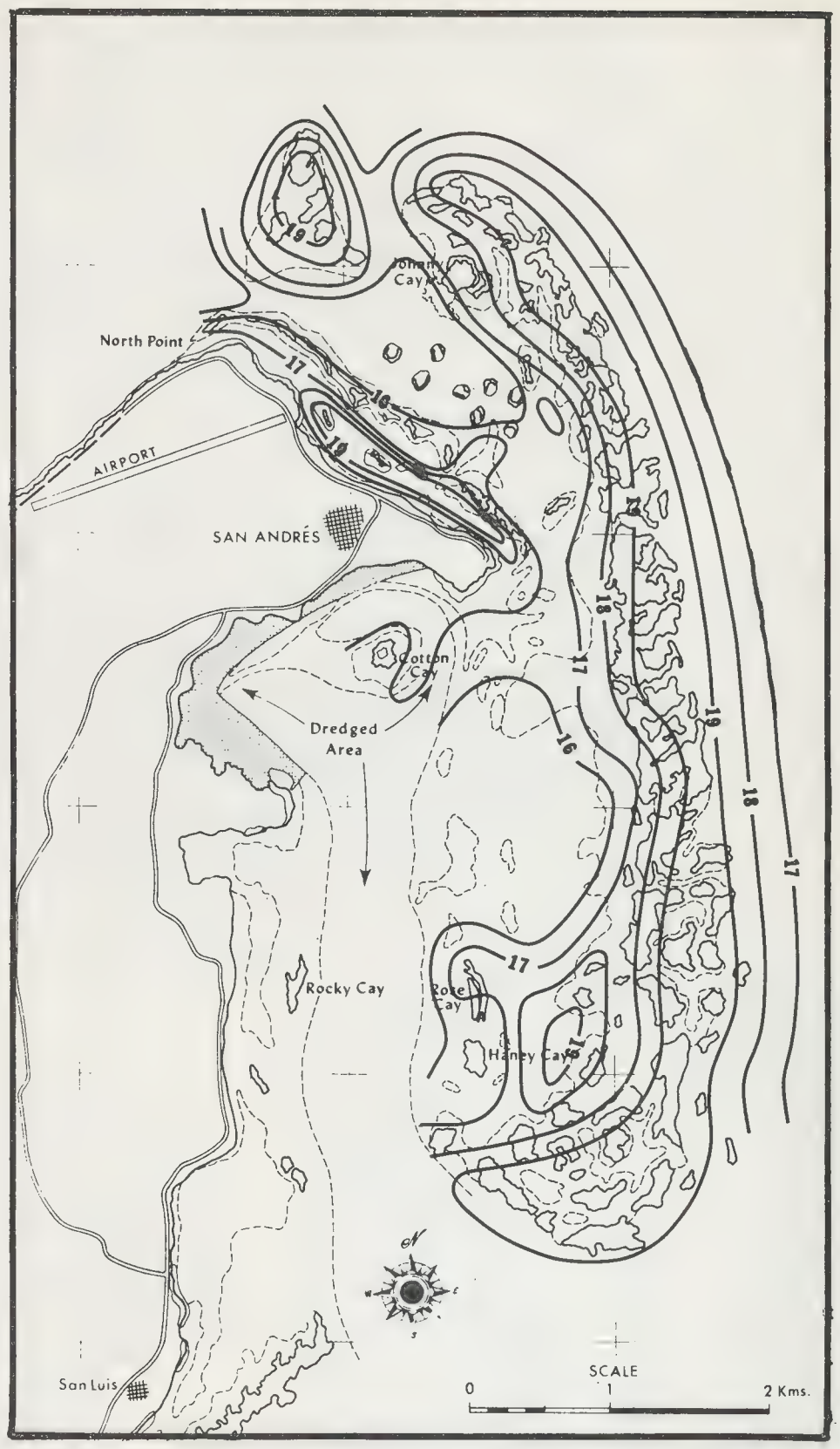

Fig. 16 – Distribution of magnesium carbonate in the San Andres area (values in mole %).

a frame builder of secondary importance. For example, Ginsburg (1953) reported *Acropora palmata* to be the major frame builder of the Florida reefs. He did, however, note that *Millepora* occupies a major fore-reef zone. Reefs along the coast of British Honduras are often built primarily by *Montastrea annularis*. Kornicker and Boyd (1962) reported *Millepora* and *Acropora palmata* as primary frame builders of the Alacran reef in Mexico. Although the same types of organisms are present in most reefs, their ecologic positions may be slightly different from area to area.

Modern reefs, along the eastern side of San Andres Island, have formed on a terrace of Pleistocene age. The dominant reef organisms are *Millepora complanata* and *Palythoa mammillosa*. Based on bottom sediment type and faunal distributions, the modern reef complex on the windward side of the island has been divided into five major ecologic zones: 1) near-shore area, 2) back-reef lagoon, 3) back-reef platform, 4) reef crest, 5) fore-reef.

Within the main reef area a distinct faunal zonation can be observed. In the fore-reef area *Montastrea annularis* is predominant and *Acropora palmata* is of secondary importance. In the reef zone, *Millepora complanta* and *Palythoa mammillosa* are the dominant forms. The immediate back-reef area is characterized by *Acropora palmata* and *Diploria strigosa.* Lime-secreting coralline algae are particularly important as cementing agents in the main reef zone and effective sediment binders in the turtle grass areas. Other algal forms are also important as sediment contributors and binders *(i.e., Halimeda, Udotea, Penicillus,* and *Rhipocephalus).* It is probable that the presence of crustose coralline algae account for the high $MgCO_3$ content (up to 20 mole %) of sediment samples from the reef and shore zone areas.

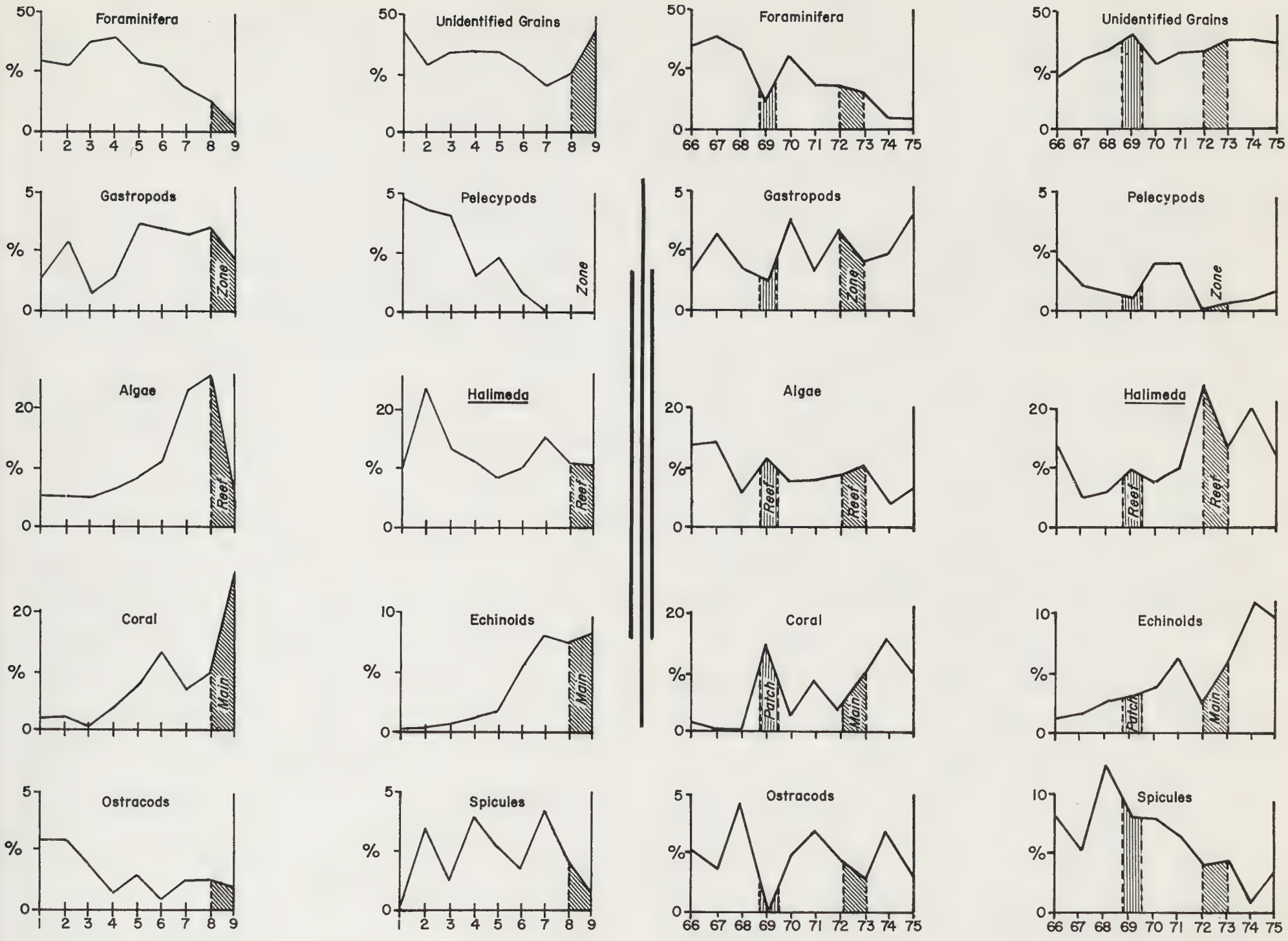

Fig. 17 – Relative changes in constituent grain percentages of samples from shore to fore reef. Samples 1 to 9 represent traverse "A", samples 66 to 75 represent traverse "H" (Fig. 13).

VII. ACKNOWLEDGMENTS

I am indebted to Union Oil Company Foundation for financial support of this project. Appreciation is also extended to John P. Brand for assistance in the field and Alonzo D. Jacka for assistance in the preparation of this manuscript. This project was part of a doctoral dissertation prepared at Texas Tech University in 1972.

VIII. LITERATURE CITED

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REVIEWS

CONTRIBUTIONS TO THE HISTORY OF GEOLOGY, edited by George W. White, a series of classical works in geology, reprinted in facsimile with introductory biographical and bibliographical commentaries by the editor and other distinguished students of the history of geology. These volumes are handsomely and skillfully reproduced and were carefully selected to make essential but almost unobtainable titles available to students and historians at relatively modest cost. Published by Hafner Press, a division of Macmillan Publishing Company, Inc., New York.

9. THE WERNERIAN THEORY OF THE NEPTUNIAN ORIGIN OF ROCKS, a facsimile reprint of *Elements of Geognosy, 1808,* by Robert Jameson; with an introduction by Jessie M. Sweet and a foreword by George W. White. New York, 1976, xxiv + xvi + 387 pp., $25.00

Robert Jameson, Regius Professor of Natural History at the University of Edinburgh (1804-1854), student of Abraham Gottlob Werner and diehard Neptunist, founder and permanent president of the Wernerian Natural History Society, and the foremost English language spokesman for Wernerian philosophy, published in 1808 the third volume of his *System of Mineralogy.* This third volume, titled *Elements of Geognosy,* presents Werner's system of rock classification and Werner's Neptunist theory of the origin of rocks to the English reader in its fullest and most complete form. This work serves as both an explanation and a defense of Werner's rock classification and his geognosy. The text is a faithful translation of Werner, augmented and expanded by Jameson from his own experience. Jameson also included long quotations from Huttonian theory and Playfair's *Illustrations,* refuting point by point the Plutonist views; and, in another section, contrasted the Huttonian Plutonist philosophy with the Wernerian Neptunist philosophy.

The influence of Jameson's explication of Wernerian ideas was enormous. It was through this volume that Werner's concepts and his classification of rocks reached English-speaking scientists throughout the world and, for the next several decades, the quite numerous references to Wernerian philosophy and classification in British and American works can be traced to the Jameson text.

In the introduction to this reprint edition, Miss Jessie M. Sweet, the principal authority on the life of Robert Jameson and his work, provides a lucid and thorough review of Jameson's life, his education, his students and associates, and his scientific work. Her contribution is well-documented and most useful.

In addition to making the Jameson work generally available to students and research scholars in the history of science, this volume will be of great assistance to understanding the relationship between Werner and one of his most devoted students and the key role that Jameson held in the controversy between the Neptunist and Plutonist schools.

—H.C.S.

PLIOCENE *VOORTHUYSENIELLA* (PROBLEMATICA) FROM THE TEXAS CONTINENTAL SHELF

DREW HAMAN*
CHEVRON U.S.A., INC., NEW ORLEANS

A ditch sample obtained from a well located in the High Island area of offshore Texas yielded an unusual form of *Voorthuyseniella* Szczechura (1969), which, because of its morphologic character and the bathymetric implications of the associated fauna is deemed worthy of description. This sample (approximately 10 ml of dry residue) is composed predominantly of shale, with subsidiary quartz and minor pyrite. The foraminiferal fauna in the sample consists of 38 benthic species with over 200 individuals and 12 planktonic species with over 600 specimens. The sparse associated fauna is composed of mollusk fragments and echinoid spines. A Pliocene age, Zone N.19 of Blow (1969), is evidenced by the fossil assemblage, which also indicates a middle bathyal (1500'-3000' water depth) environment of deposition.

While some attention has been paid to the occurrence of the genus *Voorthuyseniella* in the Gulf of Mexico (Keij, 1970; Haman and Kohl, 1976a), the taxon has generally been neglected. Consequently, it is believed advisable to publish this note in order to generate interest in this organism, to illustrate the unusual morphology and discuss the paleobathymetric implications indicated by this occurrence.

To date, *Voorthuyseniella* occurrences in the Gulf of Mexico have been noted by Keij (1970) from the Recent of offshore Texas and by Haman and Kohl (1976a) from the Pleistocene of offshore Texas. This new occurrence would extend the stratigraphic range of this problematic genus into the Pliocene of this area. The geographic and stratigraphic extent of *Voorthuyseniella,* as known to date in the Gulf Coast province, is tabulated below.

It is known from personal observations that this taxon also occurs in the late Neogene of Louisiana. These Louisiana occurrences will be reported on at a future date.

A number of authors, Huang (1962); Keij (1964); Kummerle and Gunawardena (1967); Szczechura (1969); Keij (1970); Willems (1972, 1975); and Haman and Kohl (1976a, 1976b) have either indicated from direct observation of Recent occurrences, or inferred by interpretation of the fossil occurrences, that the habitat of *Voorthuyseniella* is in a shallow water environment. The middle bathyal water depth indicated by the fauna associated with the Pliocene specimen of *Voorthuyseniella* discussed in this article suggests that this genus is not restricted to shallow water environments but is more cosmopolitan in habit. The foraminiferal fauna associated with this specimen of *Voorthuyseniella* is considered, by analogy with the data of Phleger (1951); Parker (1954); and Murray (1973); to be indigenous to the indicated middle bathyal depths. Foraminifera characteristic of more shallow depths are not present in the fauna and this indicates that the possibility of downslope displacement of this specimen can be discounted. Further, the borehole conditions preclude the possibility of this form being a contaminant from a higher stratigraphic level in the well. In general, the forms of *Voorthuyseniella* associated with a shallow water environment possess a test that is globular or elongate-globular (hemispherical) in nature (see Keij, 1970; Hantzchel 1975). The distinctly compressed type of test described herein has not been reported to date. It is suggested that the morphocharacter of this specimen is possibly related to the bathymetric parameter.

The advisability of using a ditch sample for an age or paleobathymetric interpretation may be questioned, but the planktonic suite unquestionably places this sample in the normal time framework. In addition, the papers by LeRoy and Levinson (1974) and LeRoy and Hodgkinson (1975) lend

*Research Associate, Dept. of Geology, Tulane University, New Orleans.

	TEXAS	MISSISSIPPI	ALABAMA
Recent	Keij (1970)		
Pleist.	Haman and Kohl (1976a)		
Plio.	This report		
Mio.			
Olig.		Keij (1970)	Keij (1970)
			Haman and Kohl (1976b)
Eoc.			Haman and Kohl (1976b)

TABLE 1
Known distribution of *Voorthuyseniella* in the Gulf Coast province.

credence to the paleobathymetric interpretation based on the infaunal association of the sample.

As only a single specimen of this taxon was retrieved, no attempt has been made to name the form. The purpose of this report is simply to record the occurrence by description and indicate the paleobathymetric habitat of the organism.

Test orientation, morphologic terms and measurement terminology is standardized and based on Haman and Kohl (1976b, text-figure 2).

VOORTHUYSENIELLA sp.
Plate 1, figs. 1-3; Plate 2, figs. 1-3.

Description: Test calcareous, unilocular, as high as wide, tapering from base of camera to porta, camera almost cone shaped in side view. Camera extends laterally (0.27 mm) to either side of the median line between the lateral apertures. Camera indicates compression when viewed from above (Pl. 1, fig. 3) so that ovate camera is situated transverse to tubus. Test is widest just below the middle. Tubus reasonably flat, slightly narrower at the middle compared to the ends (*i.e.*, towards the lateral apertures) (Pl. 1, fig. 2). Parallel sided furrow present on tubus running longitudinally along it, extending the entire length of the camera (Pl. 1, fig. 2). Porta elliptical (0.06 mm x 0.03 mm), situated in a slightly bevelled depression and surrounded by an elliptically shaped worn area (0.15 mm x 0.09 mm) (Pl. 2, fig. 3). Elliptical porta orientated transverse to median line between apertures. Tubus pore subcircular to elliptical (0.03 mm x 0.02 mm), situated between the lateral apertures and in line with them. Tubus pore does not extend beyond the tubus furrow. Lateral aperture A is circular to subcircular (Pl. 2, fig. 1). Lateral aperture B is broken but is evidently subcircular (Pl. 2, fig. 2). No septa are evident. Test surface under light microscope examination appears striate and punctate but with SEM examination the striae are shown to be the effect of differential solution on the camera, and the punctae are elongate depressions or dimples in the test wall, not true punctae. The shallow elongate depressions (av. 0.01 mm x 0.005 mm) are restricted to the camera and are arranged concentrically around the porta (Pl. 1, fig. 3). Solution effects are

PLATE 1
VOORTHUYSENIELLA sp.
Bar = 100 microns

Figure

1 Side view
2 View to tubus, tubus pore, and tubus furrow
3 View to porta. Note erosion around porta and depressions arranged concentrically around porta.

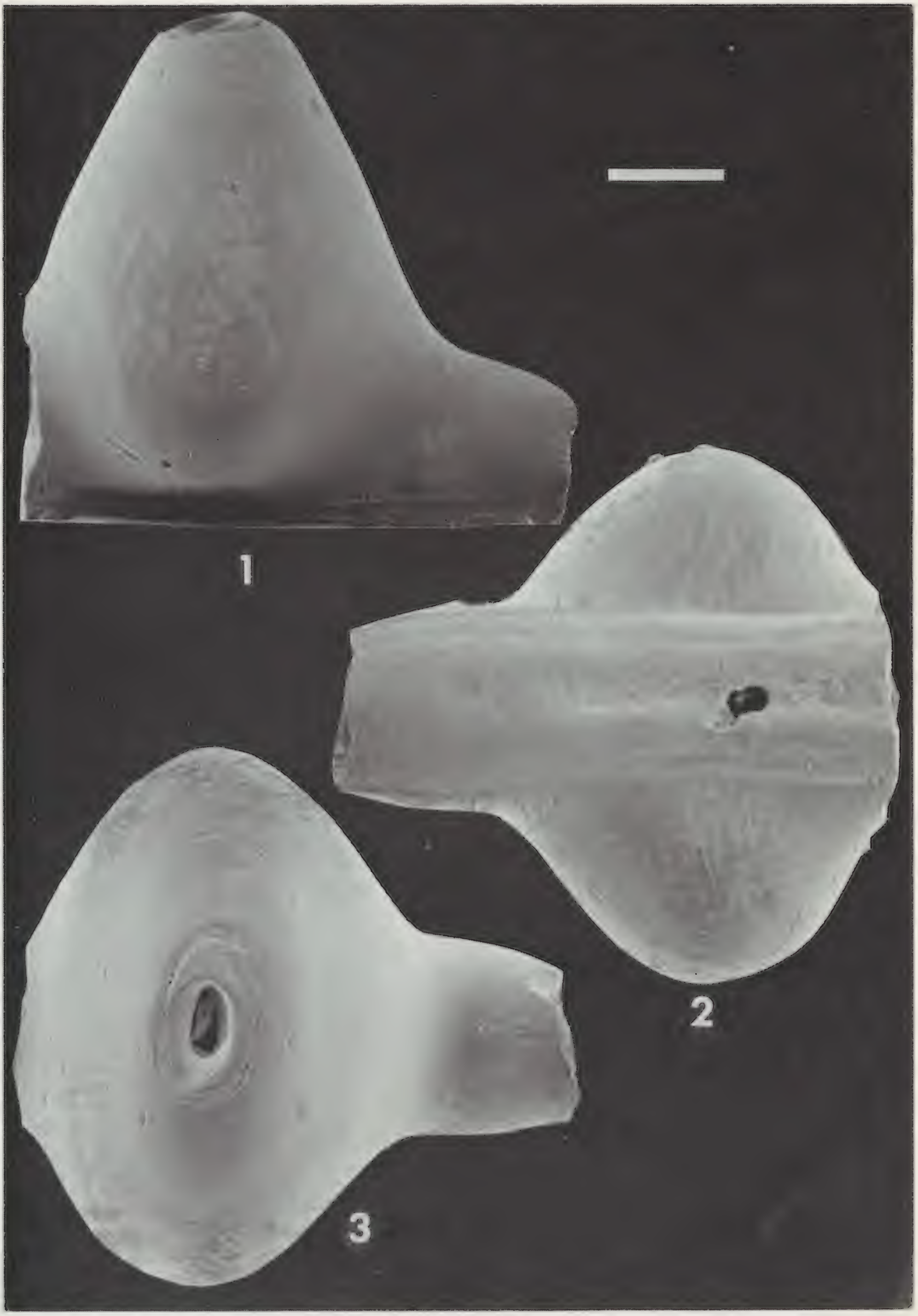

PLATE 1

not restricted to the camera but are evident over camera and tubus alike.

Test Dimensions: Max. length, 0.46 mm (B aperture broken); max. width, 0.44 mm; height, 0.43 mm.

Locality: Well cutting sample outer High Island area, offshore Texas.

Stratigraphic Level: Early Pliocene, Zone N.19 of Blow (1969).

Remarks: Superficial similarity is exhibited between this form and the dimorphic subspecies *Voorthuyseniella cornudensis cruciformis* Keij, 1970, from the Montebello Clay (Tortonian) of Italy. In detail the two forms can be readily differentiated on the nature of cameral inflation, and on the character of the tubus, tubus pore, and porta. *Voorthuyseniella* sp. does not exhibit strong affinities to any other described forms of this genus. *V. borneensis* Keij, 1964, (Recent, S. China Sea) possesses a tubus furrow as does this form but differs in all other respects. It is not believed that this new form is a variant of any of the described species but is a distinct, separate form.

The author is indebted to W. H. Akers, W.P.S. Ventress, B.L. Hill and B. Kohl for reading an early draft of the manuscript and offering constructive advice; to D. Greig for assistance with the SEM photography; to J. R. Bailey and Mrs. P. Haman for technical assistance, and to Chevron U.S.A., Inc., for allowing access to the SEM and for publication permission.

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PLATE 2

VOORTHUYSENIELLA sp.

Bar = 100 microns unless noted

Figure

1 Lateral aperture A

2 Lateral aperture B

3 Enlargement of porta with surrounding area of test dissolution. Bar = 50 microns.

PLATE 2

WILLEMS, W., 1972, Problematic microfossils from the Ypres formation of Belgium: Soc. Belge Geol., Bull., Paleont., Hydrol., vol. 81, no. 1-2, p. 53-73, figs. 1-8, 5 pls.

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November 16, 1977

COMMENTS ON THE GENUS *VIRGULINELLA* CUSHMAN, 1932 (FORAMINIFERIDA)

DREW HAMAN*

CHEVRON U.S.A., INC., NEW ORLEANS

Cushman and Ponton (1931) described *Virgulina miocenica* from the Miocene of Florida and Maryland. The specimens were recorded from the Shoal River, Choctawhatchee (?) and Oak Grove formations of Florida, and from the Choptank Formation, Chesapeake Beach, Maryland. The relationship of this species to *Virgulina pertusa* Reuss and *V. gunteri* Cushman was discussed in the same article. In 1932 Cushman erected the subgenus *Virgulinella* and selected *V. pertusa* Reuss as the subgenotype, stating (1932, p. 9), with reference to the subgenus, that "as far as known the species are limited to the Miocene." Reuss (1861) had, however, recorded *V. pertusa* from the "Miocene and Pliocene of western Europe," as noted by Cushman (1931, p. 32). The European Pliocene occurrence must have been regarded as suspect by Cushman considering his subsequent statement (1937, p. 31) that "the European species has been recorded from the Pliocene of Belgium, but there seems to be some question as to the validity of this record." The Miocene restriction of this subgenus was reiterated. However, in the same year Yabe and Asano (1937) recorded *V. lunata* as common in a sandstone of Pliocene age at Tjilegong, Bantam, West Java, unquestionably establishing a stratigraphic range extension of the subgenus into the Pliocene.

The taxon *Virgulinella* was accepted for decades as being a form of Miocene-Pliocene age, as is evidenced by Loeblich and Tappan (1964, p. C734) in their diagnosis of this taxon, which they regarded as a distinct genus. These authors indicated that the genus had a geographic extent of Europe (Germany, Netherlands) to North America and Indonesia.

Prior to the significant work of Loeblich and Tappan (1964) a report appeared that apparently has been overlooked by many authors in their analysis of this genus. In this work (Orlov, 1959) the taxon *Virgulinella* was accapted as a genus, and the species *V. pertusa* was recorded from the upper Maikop series (lower Miocene) of the Azerbaijan region, south Russia. A specimen of this species, from the collection of Z. V. Kuznetsova, was illustrated in this 1959 publication.

As this genus was originally described from the Gulf Coast province and as it has been utilized stratigraphically by many workers in this region (for example, Ellisor, 1940) the appearance of two recent papers on the taxon has prompted this short note. Two papers were published in 1976, both of which recorded *Virgulinella* from Recent sediments in the Indo-Pacific area. It is hoped that this article will emphasize the fact that the genus is not restricted to the Miocene and Pliocene on a world wide basis, and will make the record more complete by the inclusion of the Russian data. Ecologic

*Research Associate, Dept. of Geology, Tulane University, New Orleans.

data from these papers may be of assistance in paleoecologic interpretations of faunas containing this genus when such faunas are encountered in the Gulf Coast region.

Bhatia and Kumer (1976) described the Recent benthic foraminiferal fauna from 17 stations situated around Anjidiv Island, off Binge, west coast of India. These authors recorded *Virgulinella* sp. from two stations (no. 4 and no. 16) where the taxon comprised 0.19% and 0.25% respectively of the total foraminiferal fauna retrieved from these stations. The authors were unable to determine whether the specimens were alive or dead at the time of collection. In their discussion (1976, p. 244) of these occurrences, they make no mention of the possibility of the taxon having been reworked into the Recent sediments and analysis of their faunal lists indicates that there are no other taxa present to support a reworking theory. Consequently these occurrences reported as being Recent must be accepted. Environmental parameters were presented for all stations (*ibid.*, p. 241, table 1), some of which are selected here, as follows: Station 4: 13 meters water depth; 88.53% silt substrate; 29.4° C temperature; 9.5 pH; 34.56‰ salinity;4.48 ml/l dissolved oxygen. Station 16: 10.5 meters water depth; 95.74% silt substrate; 29.5° C temperature; 10.8 pH; 34.49‰ salinity; 4.52 ml/l dissolved oxygen. The authors could not speciate their form but they state "there is no doubt that we have in our material specimens of this Mio-Pliocene genus" and that "there are apparently hitherto no records from the present-day seas." This latter statement would indicate that these authors believe that the taxon is indigenous in the Recent sediments they examined.

Grindell and Collen (1976) recorded *Virgulinella fragilis* from Wellington Harbour, New Zealand. They reported empty (dead) tests at 15 stations in the harbour. The water depths at these stations range from 16-31 meters. They further recorded living specimens (as determined by the rose Bengal method of Walton, 1952) at three stations, which ranged in depth from 16-20 meters. Individual station ecologic parameters were not presented, but a summary of the habitat of *V. fragilis* was given (*ibid.*, pp. 274, 277). In general, the harbour substrate is composed of silty to sandy muds. The area undergoes a 11°-18° C seasonal temperature fluctuation. The salinity ranges from 33.5 -34.5‰, and there is no serious oxygen depletion in the turbid, efficiently mixed harbour waters. Two areas of pollution were defined in the harbour based on bacterial abundance. These areas were tentatively related to the samples that contained live specimens of this genus. The authors (*ibid.*, p. 278) noted that the tests they recovered were very fragile, and while test dimorphism could not be demonstrated, they felt that both microspheric and megalospheric generations were present. The same authors state: "Published data suggest evolution of the genus in North America or Europe in the Miocene, migration to Southeast Asia during the Pliocene, and further spread from there to New Zealand." Grindell and Collen make no reference to the Maikopian occurrence as noted by Orlov (1959), although this occurrence does not negate their dispersal hypothesis. The report of Bhatia and Kumer (1976), does not preclude the theory of Grindell and Collen (1976), although it would suggest that the post-Pliocene pattern is more complex than suggested.

In summary, the India and New Zealand occurrences of *Virgulinella* necessitate a range extension of this form from the Miocene to the Recent, although to date, no Pleistocene occurrences have been documented. The Recent occurrences of this taxon suggest that *Virgulinella* prefers a temperate to warm, shallow water habitat, (10.5-31 meters), with normal salinities, and a silty to sandy mud substrate.

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November 16, 1977

REVIEWS

FOSSILS, PALEONTOLOGY, AND EVOLUTION, by David L. Clark. Published by Wm. C. Brown Company, Dubuque, Iowa, 1976, second edition, x + 121 pp., illus., paperbound.

This book includes a brief history of paleontology and the origin of life, as well as a survey of the evolution of major groups of organisms that have left a fossil record. Four chapters deal with fossils as tools in the interpretation of Earth history, including consideration of Evolution and Biostratigraphy, Paleoecology, and Paleogeophysics. A final chapter provides a brief discussion of the possibility of extraterrestrial life, and whether, if such life should exist, it would resemble life as known on Earth.

LIFE THROUGH TIME, by Harold L. Levin. Published by Wm. C. Brown Company, Dubuque, Iowa, 1975, xi + 217 pp., illus., paperbound.

In this volume, the pageant of prehistoric life as revealed by the fossil record over the last three billion years is reviewed. The content is designed for the non-geologist undergraduate student who for aesthetic reasons desires an understanding of evolution and prehistoric life on Earth. The book is comprehensive, yet clear and readable. Included are a glossary and an index which are quite useful.

GRIT AND CLAY, by M. D. Picard. Published by Elsevier Scientific Publishing Company, Amsterdam, Oxford, and New York, 1975, xiii + 258 pp., paperbound.

How does a reviewer review a book of and about book reviews? This book is an amusing compilation of the author's published reviews interspersed with classic quotes and anecdotes. It should prove to be a pleasant experience for the reader.

—H.C.S.

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

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CARDIIDAE (MOLLUSCA: BIVALVIA) FROM THE CHIPOLA FORMATION, CALHOUN COUNTY, FLORIDA

HAROLD E. VOKES
TULANE UNIVERSITY

CONTENTS

Page
I. ABSTRACT 143
II. INTRODUCTION 144
III. DISTRIBUTION OF THE CARDIID SPECIES 145
IV. COLOR PATTERNS 149
V. ACKNOWLEDGMENTS 152
VI. SYSTEMATIC DESCRIPTIONS 152
VII. LOCALITY DATA 186
VIII. LITERATURE CITED 188

ILLUSTRATIONS

TEXT FIGURE 1 157
TABLE 1 145
TABLE 2 148
TABLE 3 150
TABLE 4 165
TABLE 5 176
TABLE 6 181
PLATE 1 147
PLATE 2 151
PLATE 3 155
PLATE 4 159
PLATE 5 163
PLATE 6 167
PLATE 7 171
PLATE 8 175
PLATE 9 179
PLATE 10 183

I. ABSTRACT

Fifteen species of cardiid bivalves are reported from the type area of the Chipola Formation in Calhoun County, Florida. These 15 species are assigned to nine genera and four subfamilies; one new subgenus, *Trachycardium (Conilocardium)* - type species *"Cardium (Trachycardium)" cestum* Dall - and five new species: *Acrosterigma (Vasticardium) hoerleorum, Papyridea miocica, Papyridea multicostula, Fragum tunicula,* and *Trigoniocardia (Americardia) decidua* are described.

More than 40,000 valves were examined during the study, with slightly more than one-third of these proving to be referrable to *Trigoniocardia (Trigoniocardia) simrothi* (Dall). This species together with *Dinocardi-*

EDITORIAL COMMITTEE FOR THIS PAPER:
SHIRLEY E. HOERLE, West Palm Beach, Florida
A. MYRA KEEN, Department of Geology, Stanford University (Emeritus), Stanford, California
KATHERINE V. W. PALMER, Paleontological Research Institution, Ithaca, New York

um chipolanum (Dall) and *Trigoniocardia (Trigoniocardia?) burnsii* (Dall) constitute almost three-fourths of the cardiid fauna.

Variation in the distribution of some of the species poses problems, probably of ecologic nature, that at present cannot satisfactorily be resolved; others appear to be of possible time/stratigraphic significance.

Use of long-wave ultraviolet light has permitted the study of latent color patterns on a number of the species; these have been of much use in confirming their generic identification.

II. INTRODUCTION

Species referrable to genera of the family Cardiidae constitute a significant element in the bivalve fauna of the type area of the Chipola Formation in Calhoun County, Florida. More than 40,000 valves representing 15 species assigned to 12 genus-groups are present in the Tulane University collections. These have been secured from 58 localities including outcrops along the Chipola River downstream from the site of the old, abandoned, Bailey's Ferry of Dall (1890-1903) and subsequent authors, as well as along the courses of Tenmile Creek, which enters the Chipola River from the west at Bailey's Ferry, and of Farley Creek which enters from the east about one and three-quarter miles downstream (up-dip) from the ferry site. A map showing the trends of these streams and the relative positions of the collecting localities has been published in *Tulane Studies in Geology and Paleontology* (1972, v. 10, p. 28).

Dall (1898, pp. 1080-1109) described ten new Chipola species that were referred to the genus *Cardium* with various subgeneric assignments. For the most part these were located as being from the "Oligocene marl of the Chipola River, Calhoun County, Florida" or from the "Oligocene of the Chipola marl, Calhoun County, Florida." Most of the species with the former localization prove to have been collected from exposures on the Chipola River in the basal part of the formation as exposed below the Bailey's Ferry site (Gardner's 1926, "one mile below Bailey's Ferry"); those with the latter localization were primarily from the lower beds of the formation as exposed along Tenmile Creek (Gardner's 1926, "one mile west of Bailey's Ferry").

In addition to the ten new species, Dall also identified as Chipola species two others that had originally been described from other non-Chipola localities. Gardner (1926, pp. 130-142) recorded the same twelve forms, although with some changes in subgeneric assignment; in addition, she described as members of the Chipola fauna two others known from other localities. She did not recognize either of these latter in the collections available to her from the Calhoun County outcrops. The first of these two, "*Cardium (Cerastoderma) chipolanum* subsp. *alumen*" (Gardner, 1926, p. 138, pl. 23, fig. 6) is present, though rare, in the Tulane University collections from the upper part of the formation along Farley Creek where it is always associated with the typical form of the species; it is here interpreted as being only a minor, apparently ecologic, variant whose greater abundance at Alum Bluff and other localities cited by Gardner may be an expression of the influences of a shallower water environment in which a more coarsely grained quartzose sandstone matrix predominates, as compared with the finer grained lime-sand matrix of the typical Chipola facies. Gardner's second Chipola species "*Cardium [Fragum (Trigoniocardia)]*" *sellardsi* (1926, p. 140, pl. 23, figs. 11-12) was described from Boynton Landing on the Choctawhatchee River in Washington County, Florida (=TU 1145). It is not represented in the Tulane University collections from the type Chipola region.

The two Chipola forms referred by Dall and by Gardner to species originally described from non-Chipola horizons and localities prove, on the basis of the much more comprehensive collections now available, to be new species and are here described, together with three previously unrecognized ones. One of the latter, here denominated *Trigoniocardia (Americardia) decidua*, n. sp., was represented in the material that Dall assigned to his "*Cardium (Fragum) Burnsii*" although most specimens are somewhat larger than the typical form of that species.

The nomenclatorial history of the species considered in the present report is given in Table 1.

III. DISTRIBUTION OF THE CARDIID SPECIES

Cardiid species occur at every locality represented in the Tulane University collections from the type area of the Chipola Formation. However, some localities are more rewarding in terms of faunal diversity than are others. Furthermore, the smaller side tributaries, Tenmile Creek and Farley Creek, are always accessible for collecting while those localities along the Chipola River banks may be submerged during intervals of high water. Therefore, the total bulk of material secured from the different localities varies to the point that a simple listing of the number of valves of a species at each separate station would yield no significant information. There are, nevertheless, differences in the distribution of the various species that appear to be of stratigraphic and/or ecologic significance. For Table 2 the outcrops on the Chipola River, which trend essentially across the strike of the strata, have been divided rather arbitrarily into an upper and a lower sequence with the division occurring a short distance upstream from the mouth of Farley Creek. The latter, which enters the Chipola from the east, meanders through a sequence that is equivalent to at least the lower half of the upper sequence; Tenmile Creek, which enters the river from the west at Bailey's Ferry a short distance upstream from the Chipola/Chattahootchee contact, traverses strata of the lower sequence.

The most ubiquitous species are *Dinocardium chipolanum* (Dall), *Trigoniocardia (Trigoniocardia?) burnsii* (Dall), *Laevicardium compressum* (Dall); almost equally as widespread although slightly less abundant are *Trachycardium (Conilocardium) cestum* (Dall), *"Trachycardium" virile* (Dall) and *Trigoniocardia (Americardia) decidua,* n. sp.

Species with distribution having a possible stratigraphic significance are: *Acrosterigma (Vasticardium) hoerleorum,* n. sp., and *Papyridea bulbosa* (Dall), both known only from the lower sequence along the Chipola

TABLE 1

This Paper	Gardner, 1926	Dall, 1898
Acanthocardia propeciliare	*Cardium (Acanthocardia) propeciliare*	*Cardium propeciliare* n. sp.
Agnocardia acrocome	*Cardium (Acanthocardia) acrocome*	*Cardium acrocome* n. sp.
Acrosterigma (Vasticardium) hoerleorum n. sp.	*Cardium (Trachycardium) inconspicuum*	*Cardium (Trachycardium) inconspicuum* Guppy
Trachycardium (Conilocardium) cestum	*Cardium (Trachycardium) cestum*	*Cardium (Trachycardium) cestum* n. sp.
"Trachycardium" virile	*Cardium (Trachycardium) virile*	*Cardium (Trachycardium) virile* n. sp.
"Trachycardium" parile	*Cardium (Trachycardium) parile*	*Cardium (Trachycardium) parile* n. sp.
Dinocardium chipolanum	*Cardium (Cerastoderma) chipolanum*	*Cardium (Cerastoderma) chipolanum* n. sp.
Dinocardium chipolanum (variant)	*Cardium (Cerastoderma) chipolanum alumen* n. subsp.	
T. (Trigoniocardia?) burnsii	*Cardium (Fragum) burnsii*	*Cardium (Fragum) Burnsii* n. sp.
Fragum tunicula n. sp.	*Cardium [Fragum (Trigoniocardia)] aliculum*	*Cardium (Trigoniocardia) alicula* n. sp.
T. (Trigoniocardia) simrothi	*Cardium [Fragum (Trigoniocardia)] simrothi*	*Cardium (Trigoniocardia) Simrothi* n. sp.
T. (Americardia) decidua n. sp.		
Papyridea bulbosa	*Cardium (Papyridea) bulbosum*	*Cardium (Papyridea) bulbosum* n. sp.
Papyridea miocica n. sp.		
Papyridea multicostula n. sp.		
Laevicardium compressum	*Cardium (Laevicardium) compressum*	*Cardium (Laevicardium) compressum* n. sp.

River and Tenmile Creek, and *"Trachycardium" parile* (Dall), *Papyridea miocica,* n. sp., and *P. multicostula,* n. sp., found only in collections from the upper sequence along the river and Farley Creek. *Fragum tunicula,* n. sp., is known solely from the stratigraphically higher beds but since it is represented only by two valves in the Chipola River area this restriction may not be significant.

Acanthocardia propeciliare (Dall) also is primarily a species of the fauna of the stratigraphically higher beds of the formation with 1226 of the 1251 valves counted coming from that part of the section; however, the remaining 25 valves are from the lower strata exposed along the Chipola River, three of them having been collected from the lowest exposures immediately adjacent to the contact with the underlying Chattahootchee Formation. Hence the distribution of this species appears to be more a factor of ecologic than of purely stratigraphic control.

The most obvious example of the action of some type of ecologic control is afforded by the distribution of *Trigoniocardia (Trigoniocardia) simrothi* (Dall). This is the most abundant cardiid species in the collections, being represented by 13,702 valves, of which 10,506 come from the exposures of the lower sequence along the Chipola River. In contrast, there are but two valves in the Tenmile Creek collections, one from the immediate basal contact at TU 830, the other a little higher in the section at TU 196. The comparative list (Table 3) of the number of valves of the species known from the basal contact on the Chipola River (TU 547 + 810) and from approximately five feet stratigraphically higher (TU 554) as contrasted with the basal bed on Tenmile Creek (TU 830) and approximately five feet higher (TU 546) clearly indicates that there is some significant environmental factor involved, especially since the two areas are less than 1.5 miles distant one from the other.

Examination of Tables 2 and 3 clearly reveals that *T. simrothi* is but the extreme example of a pronounced faunal difference between the two areas. *Agnocardia acrocome, Papyridea bulbosa* and *Acrosterigma (Vasticardium) hoerleorum* reveal the reverse situation in that they are not rare in the Tenmile Creek collections but are represented from the localities along the Chipola River by two *(A. acrocome)* or three *(P. bulbosa, A. hoerleorum)* valves. Indeed, every species on the lists, other than *Trachy-*

PLATE 1

Figures Page

1, 2. *Acanthocardia propeciliare* (Dall) 152

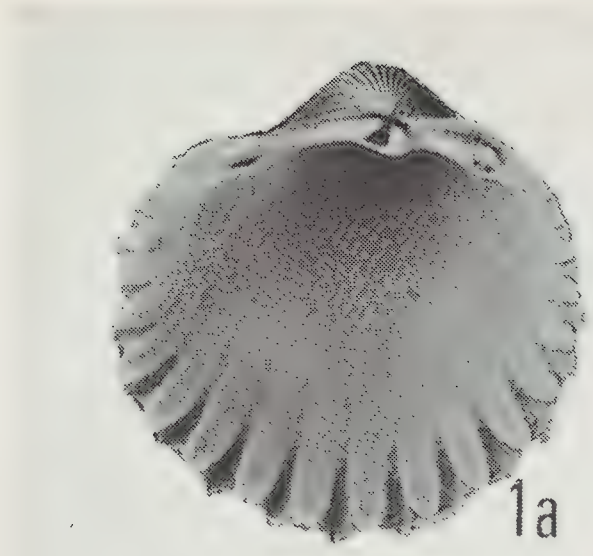
1. Figured specimen, USNM 243507 (X 2); height 17.8 mm, length 17.3 mm. Locality: TU 821, Farley Creek.
2. Figured specimen, USNM 243508 (X 2); height 21.3 mm, length 20.8 mm. Locality: TU 821, Farley Creek.

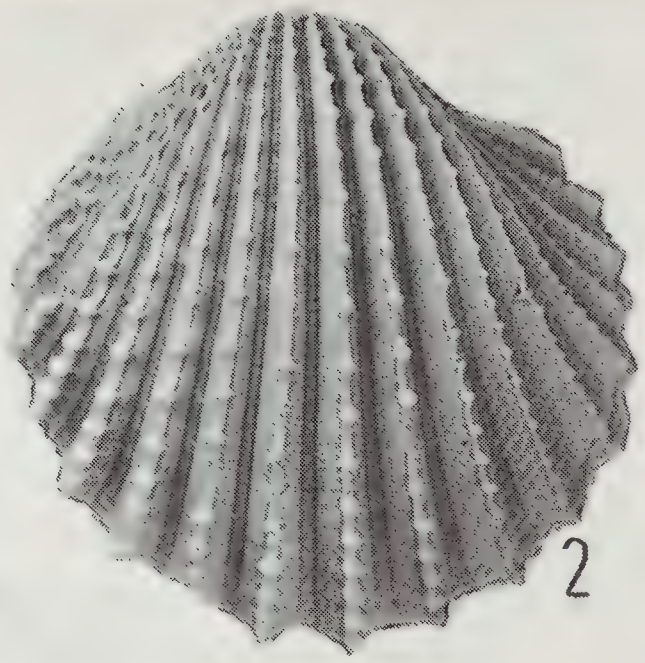
3-5. *"Trachycardium" virile* (Dall) 154

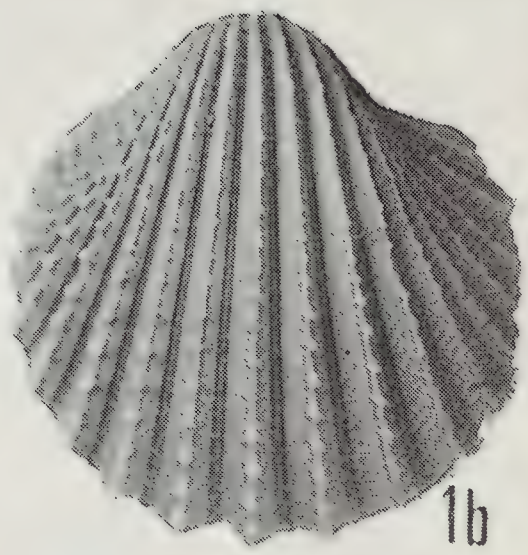
3. Figured specimen, USNM 243509 (X 1.5); height 30.7 mm, length 28.7 mm. Locality: TU 951, Tenmile Creek.
4. Figured specimen, USNM 243510 (X 1.5); height 26.4 mm, length 23.3 mm. Locality: TU 554, Chipola River. Note that the three most anterior costae of the posterior series bear oblique scalelike serrations on both anterior and posterior sides.
5. Figured specimen, USNM 243511; height 19.1 mm, length 18.1 mm. Locality: TU 817, Tenmile Creek. 5a. Exterior of valve (X 2). 5b. Detail of surface ornamentation (X 4).

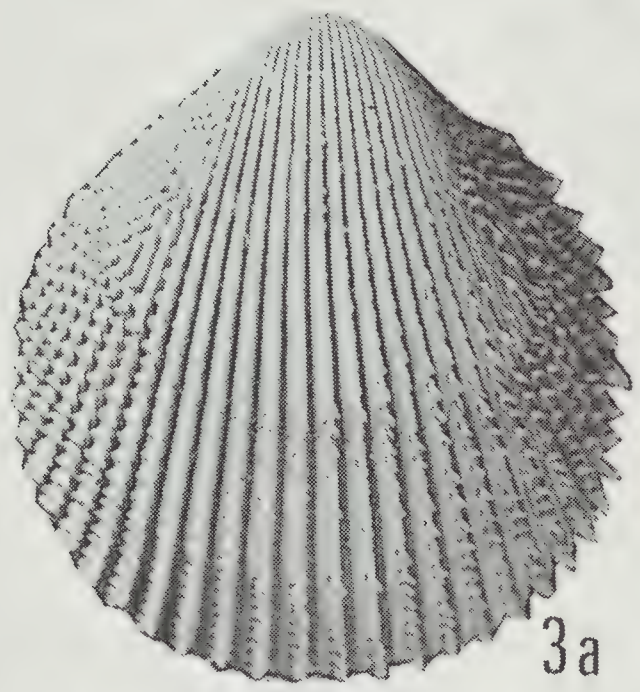
6. *Agnocardia acrocome* (Dall) 153

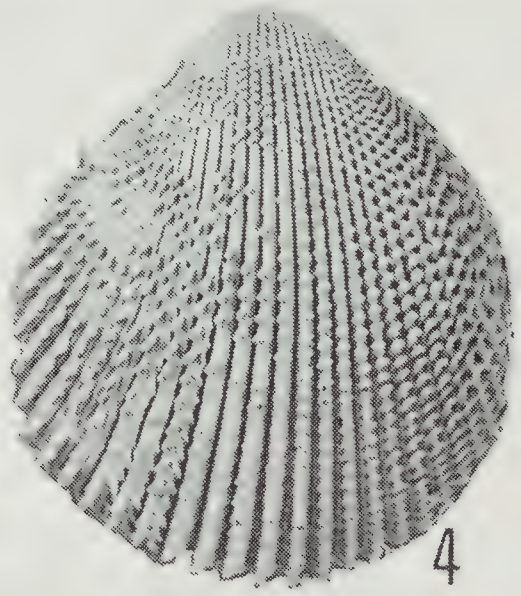
Figured specimen, USNM 243512; height 37.5 mm, length 35.5 mm. Locality: TU 830, Tenmile Creek. 6a. Detail of surface ornamentation (X 4). 6b. Exterior of valve (X 1.5).

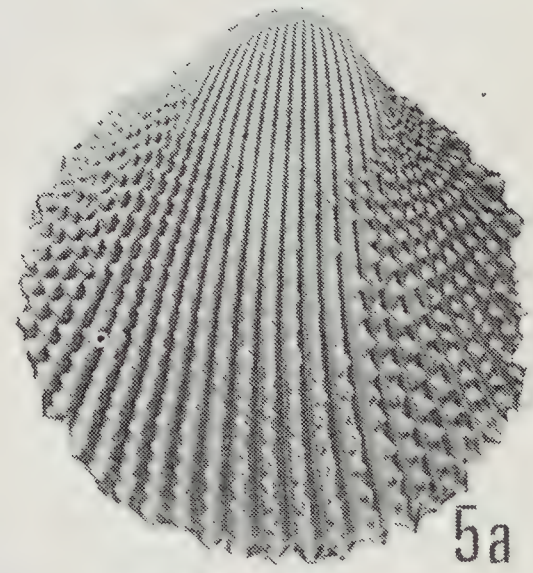


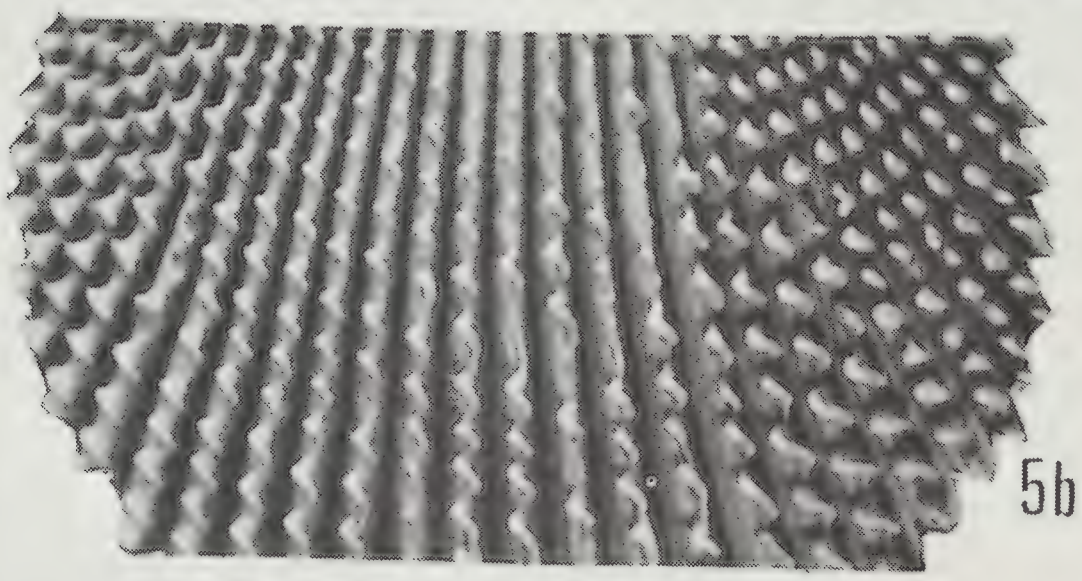


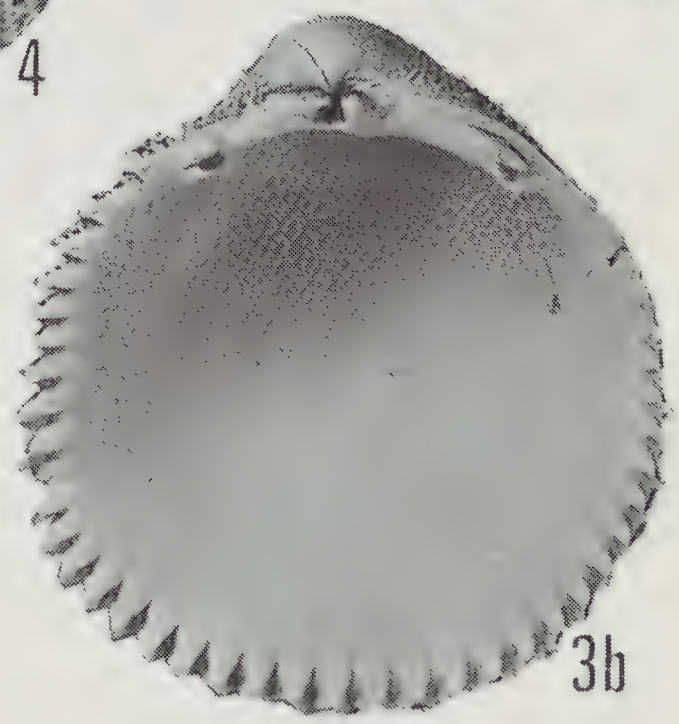


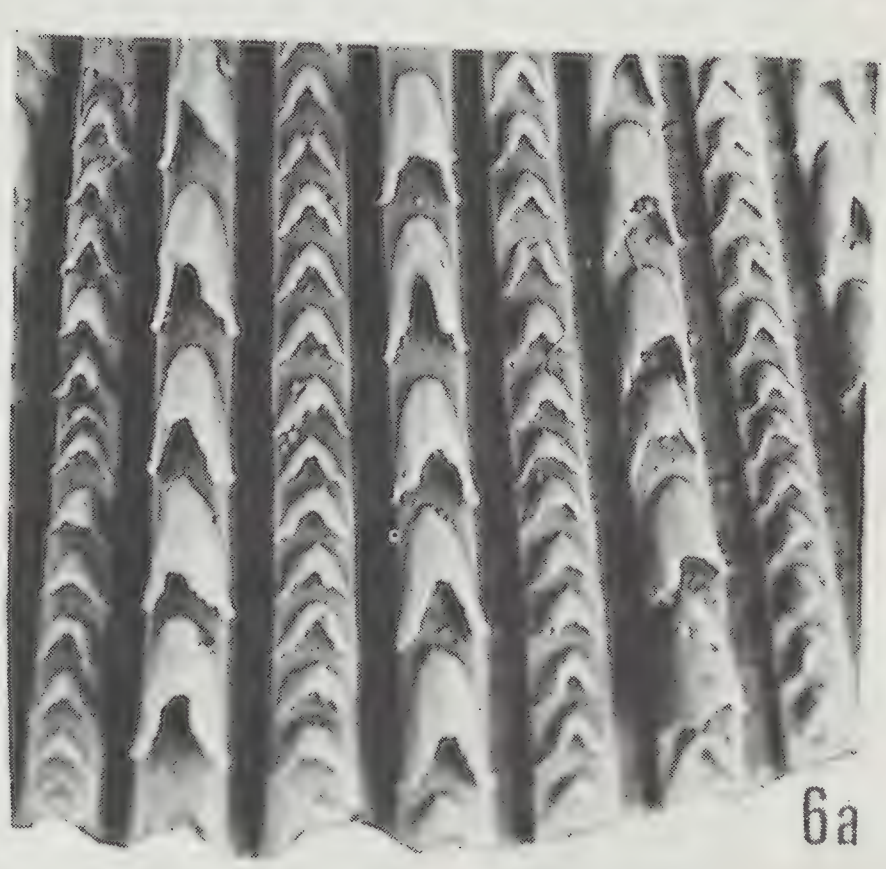












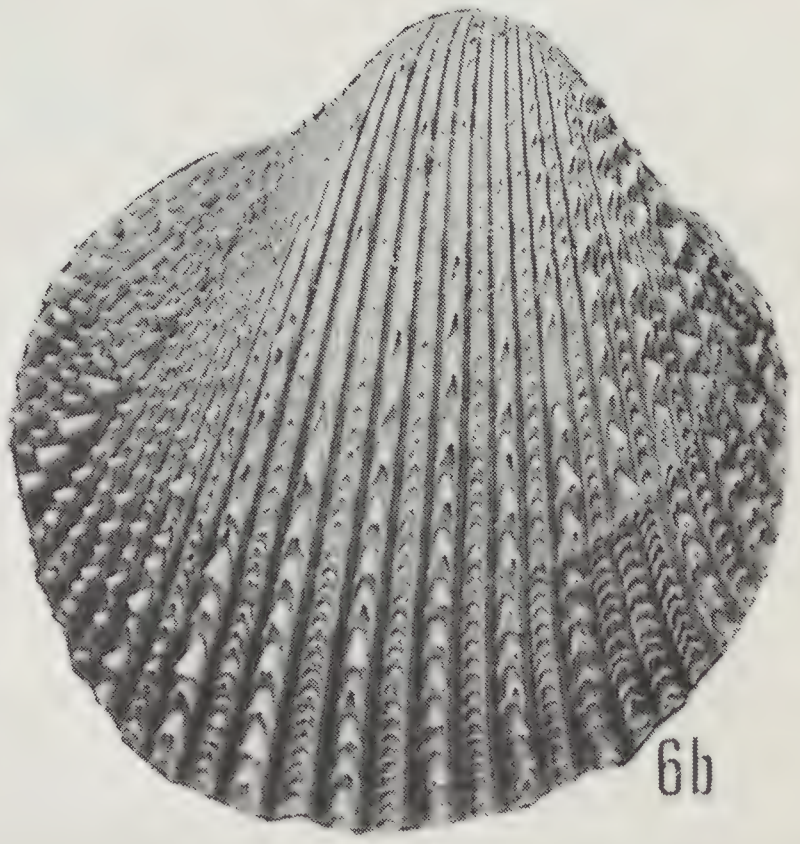


PLATE 1

TABLE 2

	LOWER SEQUENCE				UPPER SEQUENCE				TOTAL TYPE AREA CHIPOLA FM.	
	Tenmile Creek				Chipola River		Farley Creek			
	#	%	#	%	#	%	#	%	#	%
Acanthocardia propeciliare (Dall)	1	+	24	.21	679	6.11	547	9.64	1251	3.10
Agnocardia acrocome (Dall)	46	.37	0	—	2	.02	0	—	48	.12
"Trachycardium" virile (Dall)	1051	8.48	109	.98	67	.60	18	.32	1245	3.09
"Trachycardium" parile (Dall)	0	—	0	—	364	3.27	13	.23	377	.93
Trachycardium (Conilocardium) cestum (Dall)	202	1.63	197	1.77	1464	13.16	556	9.80	2419	6.00
Acrosterigma (Vasticardium) hoerleorum n. sp.	46	.37	3	.03	0	—	0	—	49	.12
Papyridea bulbosa (Dall)	28	.23	3	.03	0	—	0	—	31	.08
Papyridea miocica n. sp.	0	—	0	—	198	1.78	89	1.57	287	.71
Papyridea multicostula n. sp.	0	—	0	—	81	.72	125	2.20	206	.51
Fragum tunicula n. sp.	0	—	0	—	2	.02	0	—	2	+
Trigoniocardia (Trigoniocardia) simrothi (Dall)	2	.02	10506	94.20	2887	25.96	307	5.41	13702	33.96
Trigoniocardia (Trigoniocardia?) burnsii (Dall)	3711	29.92	200	1.79	1268	11.40	1979	34.87	71.58	17.74
Trigoniocardia (Americardia) decidua n. sp.	222	1.79	14	.12	86	.77	813	14.36	1135	2.81
Laevicardium compressum (Dall)	2617	21.55	34	.30	1169	10.51	182	3.21	4056	10.05
Dinocardium chipolanum (Dall)	4413	35.60	63	.56	2854	25.66	1046	18.43	8376	20.76
	12393	99.99	11153	99.99	11121	99.98	5675	100.04	40342	99.98

In each of the sequences above the column headed "#" represents the number of valves of each species present in the collections from the area concerned. The column headed "%" represents the percentage representation of that species relative to the total number of valves.

cardium (Conilocardium) cestum, reveals a preference for one area or the other and even *T. cestum* is more abundant in the basal Chipola River collections listed in Table 3 than it is in the comparable Tenmile Creek ones.

This situation is not unique to the cardiid species. The muricid gastropod *Chicoreus lepidotus* E. H. Vokes is, she informs me, represented by 111 specimens from the lower sequence along the Chipola River (including 32 and 68 from TU 457 and 554, respectively), but that only a single specimen has been found along Tenmile Creek (from TU 830), and Hoerle (1976, p. 17) stated that of 250 specimens of *Conus aquoreus* S.E. Hoerle, only two were from TU 830, with all of the rest from the Chipola River localities, it being "a common species at both the type locality, TU 554, and TU 457 ('one mile below Bailey's Ferry')." The reverse situation is noted for *Conus ambonos* S. E. Hoerle (1976, p. 13), *C. vergrandis* S. E. Hoerle (p. 18), *C. tricoratus* S. E. Hoerle (p. 20), and *C. rapunculus* S. E. Hoerle (p. 21), all being much more abundantly represented in the Tenmile Creek collections than in those from the Chipola River. The same situation holds true for several species of *Chicoreus (Siratus)* (E. H. Vokes, 1970, p. 51, and personal communication).

No explanation for the differences in the faunas of these two relatively approximate and stratigraphically equivalent areas is immediately apparent. Undoubtedly it is due to some ecologic factors, but their nature is as yet unknown. The sediment from the lower strata in the two areas appears to be identical in nature, being a medium to fine-grained lime-sand that, when dissolved, proves to have a small clay fraction; the amount being essentially the same in each area. Higher beds along the Tenmile Creek section reveal a change of facies, becoming a blue-gray, fine-grained sandy to silty, micaceous mudstone with appreciably lower calcium carbonate content than that of the basal marls. The fauna also changes, containing many thin-shelled tellinid species plus other forms of softer-bottom habit. Some Bryozoa from this part of the section show evidences suggestive of slightly reduced salinities (Scolaro, 1968, unpubl. diss.). This part of the section we interpret as representing a shallow-water lagoonal facies, perhaps a back-reef area. There is, however, no evidence that would indicate that such a condition was present during the time of the deposition of the basal beds here concerned, although it may be possible that a near-by reef was affecting water circulation to some extent. Solitary corals and small heads of colonial types occur frequently at all of the localities cited in Table 3 and there is no noticeable difference in the abundance or specific composition of these forms between the Tenmile Creek and the Chipola River stations.

IV. COLOR PATTERNS

Through the utilization of a commercial laundry bleach (sodium hypochlorite) and a long-wave ultraviolet light, it has been possible to reveal the color patterns characteristic of certain of the species here treated (see Vokes and Vokes, 1968, p. 76). These are illustrated on plates 9 and 10. In the majority of cases the patterns are not strikingly different from those to be observed on Recent species of the same genus. Thus the pattern exhibited by *Trachycardium (Conilocardium) cestum* (Dall) (Pl. 9, figs. 1, 2) is wholly comparable to that present on *T. isocardia* (Linnaeus), type of the genus *Trachycardium;* that of *Dinocardium chipolanum* (Dall) (Pl. 9, fig. 8) is not to be differentiated from that of *D. robustum* (Solander), type of *Dinocardium* Dall; while the patterns revealed on the three species of *Papyridea* (Pl. 9, figs. 3-5) may each be matched by one of the many rose-tinted color variants of *P. soleniformis* (Bruguière), type of that genus. Specimens of *Laevicardium compressum* (Dall) show a variable pattern of zig-zag markings that may be apparently confined to certain growth stages (Pl. 9, fig. 2b) or may intersect across the entire surface (Pl. 9, fig. 2a); similar variations may be observed on *L. laevigatum* (Linnaeus), on *L. mortoni* (Conrad), and on *L. pictum* (Ravenel) of the Recent western Atlantic faunas. And it may be noted that the pattern of more or less isolated and discrete dark spots or blotches seen on *"Trachycardium" parile* (Dall) (Pl. 9, fig. 7) is not too different from that to be observed on specimens of *T. muricatum*

TABLE 3

	Chipola River		Tenmile Creek	
	(547+810)	(554)	(830)	(546)
Acanthocardia propeciliare (Dall)	3	17	1	0
Agnocardia acrocome (Dall)	0	0	20	11
"Trachycardium" virile (Dall)	17	68	260	360
Trachycardium (Conilocardium) cestum (Dall)	48	117	34	59
Acrosterigma (Vasticardium) hoerleorum, n. sp.	1	1	23	13
Papyridea bulbosa (Dall)	0	0	10	12
Trigoniocardia (Trigoniocardia) simrothi (Dall)	1202	6667	1	0
Trigoniocardia (Trigoniocardia?) burnsii (Dall)	85	62	1043	1352
Trigoniocardia (Americardia) decidua, n. sp.	4	8	57	67
Laevicardium compressum (Dall)	6	10	79	489
Dinocardium chipolanum (Dall)	15	24	353	804
Total number of valves present	1381	6974	1881	3167

(Linnaeus), while that seen on specimens of *"T." virile* (Pl. 10, figs. 4,5) is more like that to be seen on younger, more immature specimens of the type species, *T. isocardia* (Linnaeus).

Acrosterigma (Vasticardium) hoerleorum, n. sp., has a pattern that is very like that of *A. (V.) elongatum* (Bruguière), type species of the subgenus (compare Pl. 10, figs. 1 & 2) and is wholly unlike that of *Acrosterigma dalli* (Heilprin), type of the genus, which is here illustrated for the first time (see Pl. 10, fig. 3). It is also worthy of note that the interior of *A. (V.) hoerleorum* has the same deeply colored posterior margin as is present in *A. (V.) elongatum* (compare Pl. 10, figs. 1b & 2b).

No modern species with a design similar to that of *Acanthocardia propeciliare* (Dall) is known to the writer. In general, it is only the beaded nodes that show a dark coloration with, however, the tint occasionally being extended down on to the top of the ribs immediately adjacent to the bead to

PLATE 2

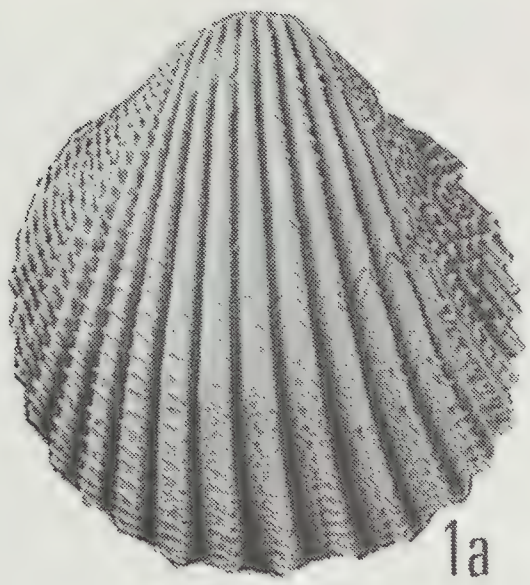
Figures Page

1, 3. *"Trachycardium" parile* (Dall) 156

1. Figured specimen, USNM 243513 (X 1.5); height 24.8 mm, length 23.0 mm. Locality: TU 547, Chipola River.
2. Figured specimen, USNM 243514; height 22.1 mm, length 22.0 mm. Locality: TU 547, Chipola River.
2a, b. Exterior and interior of valve (X 1.5). 2 c, d. Details of valve ornamentation (X 4).

3-7. *Trachycardium (Conilocardium) cestum* (Dall) 158

3. Figured specimen, USNM 243515 (X 1); height 42.0 mm, length 36.2 mm. Locality: TU 458, Chipola River.
4. Figured specimen, USNM 243516 (X 1); height 47.5 mm, length 36.8 mm. A proportionately higher specimen than usual. Locality: TU 555, Chipola River.
5. Figured specimen, USNM 243517 (X 1); height 35.0 mm, length 29.9 mm. Locality: TU 458, Chipola River.
6. Figured specimen, USNM 243518 (X 1); height 27.1 mm, length 24.6 mm, diameter (paired valves) 21.0 mm. Locality: TU 458, Chipola River.
7. Figured specimen, USNM 243519 (X 4); height 42.5 mm, length 34.0 mm. Locality: TU 458, Chipola River.
Detail of surface ornamentation; note the fine pustules on the sides of the costae and in the interspaces.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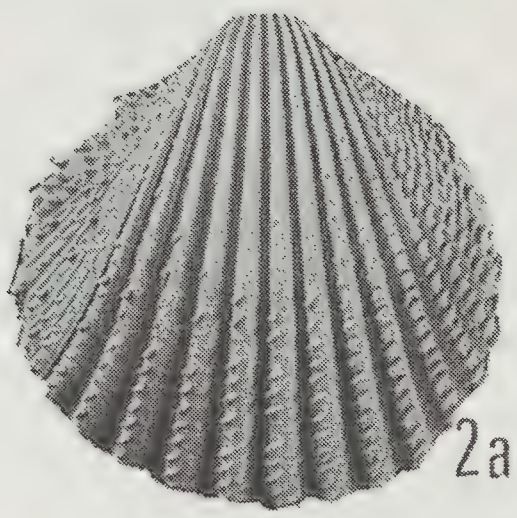
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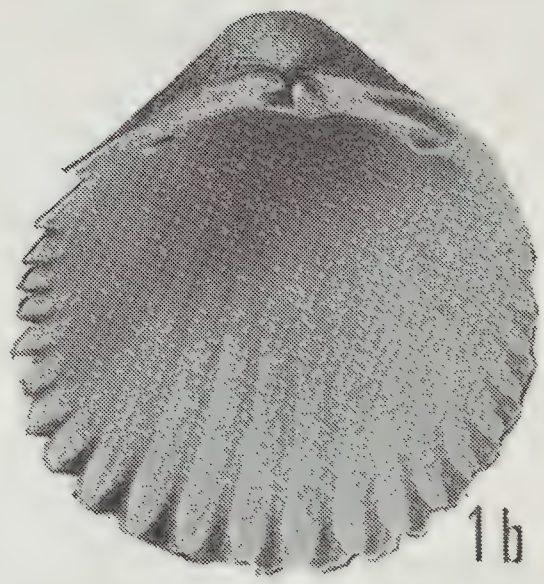
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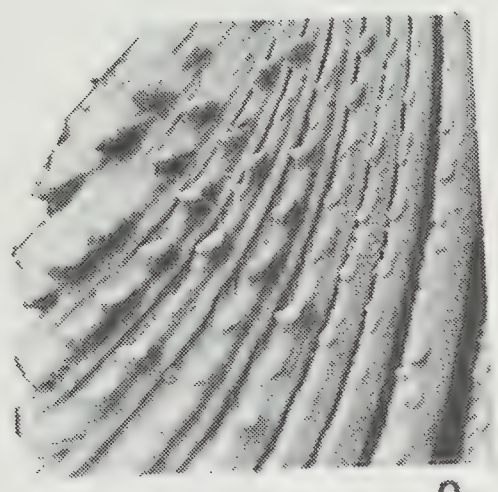
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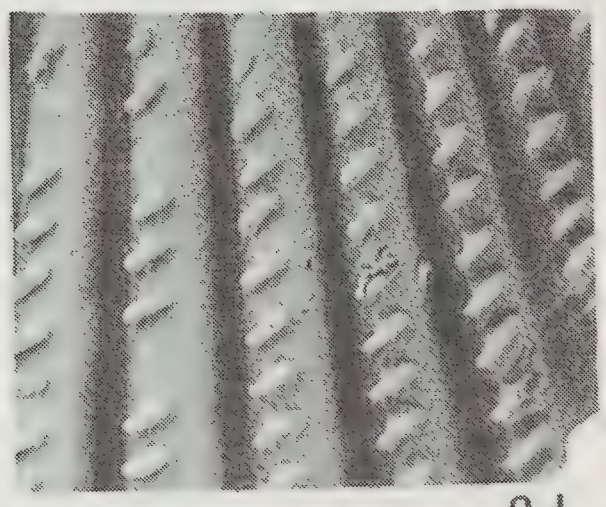
2b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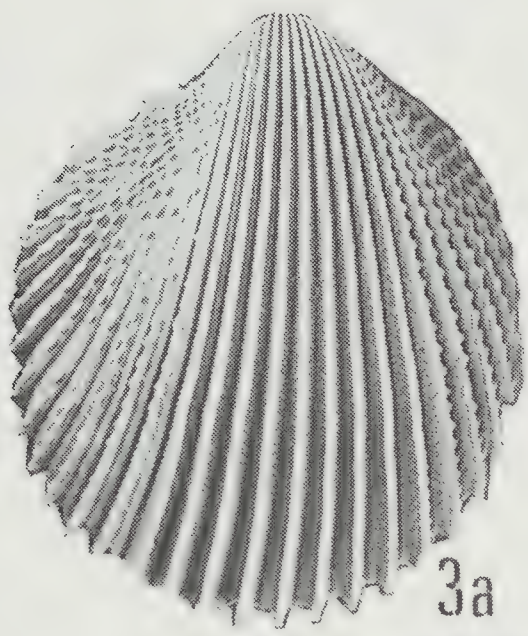
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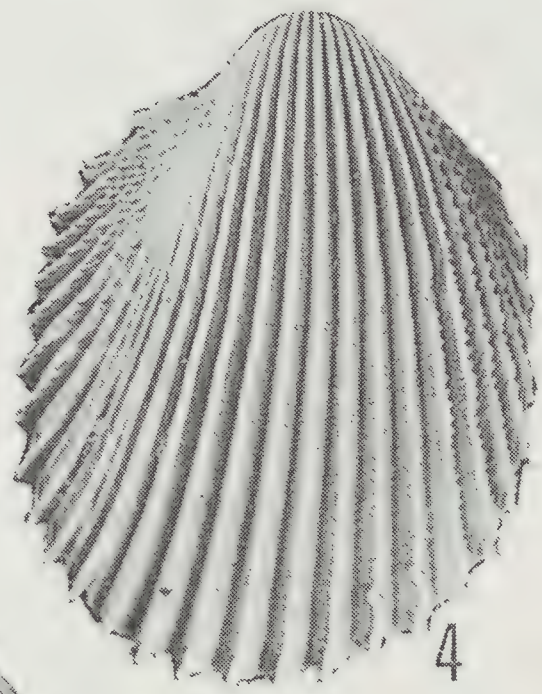
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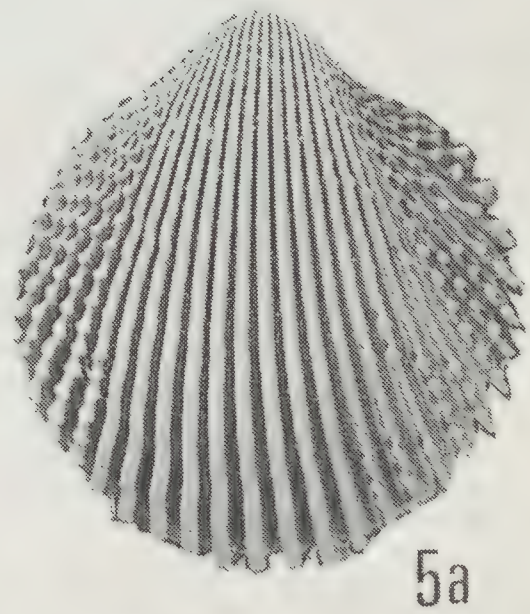
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6

7

5b

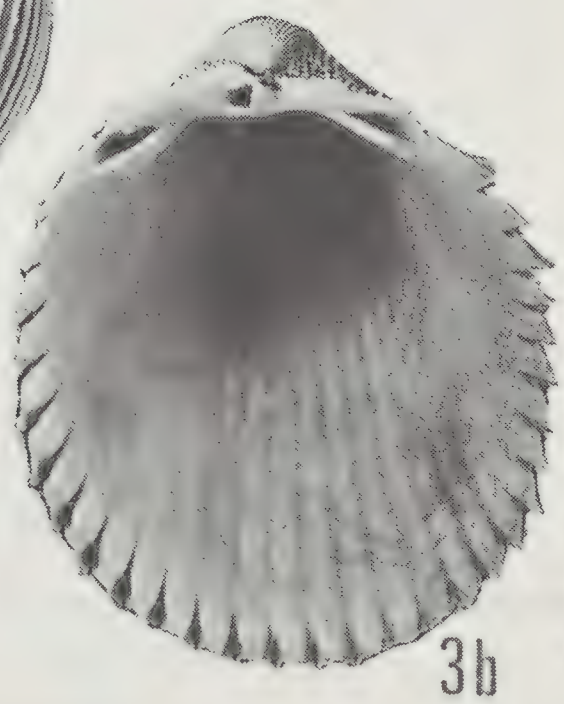
3b

PLATE 2

give a definitely rounded spot; it is almost as if the coloring material had flowed down from the top of the bead.

No recognizable distinctive coloration could be developed on *Acrocardium acrocome* (Dall) nor on any of the species here referred to the subfamily Fraginae, including *Fragum tunicula,* n. sp., *Trigoniocardia simrothi* (Dall), *T. burnsii* (Dall) or *T. (Americardia) decidua,* n. sp. Many of the Recent species referred to the Fraginae are white in color and it may well be that this condition also was characteristic of the species here concerned.

V. ACKNOWLEDGMENTS

The writer is greatly indebted to Thomas R. Waller of the United States National Museum for the loan of type and referred specimens and to Druid Wilson of the U.S. Geological Survey for additional information on specimens studied by Dall and Gardner. Mrs. R. C. Hoerle of West Palm Beach, Florida, was most generous in the use of the species in the Hoerle collections, and the writer's wife and scientific colleague aided greatly in all stages of the preparation of the manuscript; her suggestions were most helpful.

The careful reading and thoughtful comments offered by the members of the Editorial Committee are much appreciated.

VI. SYSTEMATIC DESCRIPTIONS

Family CARDIIDAE Lamarck, 1809
Subfamily CARDIINAE Lamarck, 1809
Genus ACANTHOCARDIA Gray, 1851

Acanthocardia GRAY, 1851, List of British Animals in the Collections of the British Museum, pt. 7, p. 23.

Type species, by subsequent designation, Stoliczka, 1870, *Cardium aculeatum* Linnaeus, 1758. Recent; Atlantic Coast of Europe from southern England to Iberian Peninsula, the Mediterranean and Adriatic Seas and southward to Morocco.

ACANTHOCARDIA PROPECILIARE (Dall)
Plate l, figures 1, 2; Plate 9, figure 6

Cardium propeciliare DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1080; *ibid.,* 1903, v. 3, pt. 6, pl. 48, fig. 12; SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 131 [Holotype, USNM 114768; "Oligocene. Chipola River, Calhoun County, Florida"].

NOT *Cardium (Trachycardium) propeciliare* Dall. DALL, 1915, U. S. Natl. Mus., Bull. 90, p. 142, pl. 18, fig. 7 [=*Cardium (Cerastoderma) phlyctaena* Dall, 1900].

Cardium (Acanthocardia) propeciliare Dall. GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 132, pl. 22, fig. 5 ["Type locality : No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla."].

This attractive species is one of the most distinctive and easily recognized cardiids in the Chipola fauna. The number of ribs varies between 18 and 21, usually 19 or 20; they are characteristically trigonal with smooth sides and with their crests raised above the slopes to form a distinct keel that is surmounted by round topped or knobbed spines. The inter-rib areas are flat bottomed, separated from the sloping costal sides by a narrow vertical rise that gives the areas an almost gutter-like appearance. The "cross-striated" ornamentation mentioned by Dall in his description tends to vary over the valve areas. In the better preserved specimens of the present collections the transverse ornament of the intercostals on the median and postero-median surfaces has the appearance more of a ladder-like arrangement of raised growth lamellae, and only toward the anterior and posterior ends does it suggest striations.

Dall described this species only as from the "Oligocene marl of the Chipola River, Calhoun County, Florida," and, in 1905 he essentially repeated this locality when he designated USNM specimen 114768 as the holotype (*in* Schuchert *et al.,* p. 131). Gardner (1926, p. 132) cited the type locality as USGS 2213, "1 mile below Baileys Ferry . . . ", indicating that it was rare in the collections. In the much more extensive Tulane University collections this species proves to be most abundant in the upper portion of the formation as exposed on the Chipola River and along Farley Creek (see Table 2). It is relatively rare in the collections from the lower beds that appear to be the equivalents of those from which the collections were made that were studied by Dall and Gardner. Only a single, immature valve has been obtained from Tenmile Creek,

suggesting some aspect of ecologic control of the distribution of the species, which is not readily apparent at this time. The single valve is from the basal portion of the formation where the lithology seems more similar to that of the stratigraphically equivalent deposits exposed in the banks of the Chipola River than are the upper strata of the Tenmile Creek section. These latter are notably more silty and with a decidedly smaller lime content than is found in the deposits along the river.

Figured specimen, USNM 243507; height 17.8 mm, length 17.3 mm, diameter (left valve) 7.7 mm; locality TU 821 (Pl. 1, fig. 1).

Figured specimen, USNM 243508; height 21.3 mm, length 20.8 mm, diameter (left valve) 9.4 mm; locality TU 821 (Pl. 1, fig. 2).

Figured specimen, USNM 243558; height 25.1 mm, length 22.6 mm, diameter (left valve) 10.7 mm; locality TU 555 (Pl. 9, fig. 6).

Genus AGNOCARDIA Stewart, 1930

Agnocardia STEWART, 1930, Acad. Nat. Sci. Phila., Spec. Publ. 3, pp. 37, 264.

Type species, by original designation, *Cardium (Trachycardium) claibornense* Aldrich. Middle Eocene (Claibornian); Gulf Coastal states.

AGNOCARDIA ACROCOME (Dall)

Plate 1, figure 6

Cardium acrocome DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1081; 1903, *ibid.,* v. 3, pt. 6, pl. 48, fig. 2; SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 128 [Holotype, USNM 114759; "Oligocene, Chipola River, Calhoun County, Florida"].

Cardium (Acanthocardia?) acrocome (Dall). WOODRING, 1925, Carnegie Inst. Wash., Publ. 366, p. 135 [compared to *C. (A?) dissidepictum* Woodring].

Cardium (Acanthocardia) acrocome Dall. GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 133, pl. 22, fig. 7.

Trachycardium (Agnocardia) acrocome (Dall). STEWART, 1930, Acad. Nat. Sci. Phila., Spec. Publ. 3, p. 265.

Dall's type and only specimen was a worn and immature individual: "Alt. 7.5, lon. 7.5, diam. 6 mm."* The largest specimen in the Tulane collection, a right valve from TU 830, has dimensions as follows: height 49.1 mm, length 46.5 mm, diameter 20.5 mm. The Hoerle Collection contains an even larger left valve from TU 951 with a height of 55.5 mm and a length of 46.7 mm.

The number of costae varies from 45 to 47, the majority of the specimens showing 46. On the median and anterior costae there is a regular alternation of those bearing large triangular hollow spines with those having much smaller such spines (Pl. 1, fig. 6a). The large spines clearly suffer from breakage during fossilization and collection; one fragmentary specimen from TU 951, which when complete was probably about 38 mm high, has one spine preserved that is 5.2 mm high with the tip showing slight breakage suggesting a length of as much as 6 mm. Dall stated that "on the posterior area nearly all of the ribs have low spines." This may reflect the worn condition of the valve as shown in the original illustration. The present specimens reveal an interestingly varied pattern. The postero-ventral angulation is marked by a strong-spined rib, this is followed posteriorly by a low-spined one, then another strong-spined, with four low-spined intervening before the next strong-spined one. Posterior to this there are three or four low-spined ones followed by two or three strong-spined ribs near the postero-dorsal corner.

This species is almost wholly confined to the lower strata of the Chipola Formation on Tenmile Creek and is rare at all localities where found. There are no specimens in either the Tulane nor the Hoerle collections from the area of "one mile below Bailey's Ferry," said by Gardner to be the type locality. Oddly enough, the only two specimens in the collections from the Chipola

*It is to be noted that all of Dall's dimensions of Chipola cardiid species clearly cite the diameter as though it was that of paired valves. This form of citation holds even for species where only a single valve was known; *e.g. "Cardium (Acanthocardia)" acrocome* and *"Cardium (Papyridea)" bulbosum,* of which Gardner (1926, p. 142) said "The type is unique . . . ", for which the cited dimensions are "Long. 27, alt. 23.5, diam. 10 mm."

River banks, a large left valve from TU 547 and a small individual from TU 549, are both from strata relatively high in the geologic section.

Figured specimen, USNM 243512; height 37.5 mm, length 35.5 mm, diameter (right valve) 10.7 mm; locality TU 830 (Pl. 1, fig. 6).

Subfamily TRACHYCARDIINAE
Stewart, 1930
Genus TRACHYCARDIUM
Mörch, 1853

Trachycardium MÖRCH, 1853, Catalogus Conchyliorum . . . Comes de Yoldi, fasc. 2, p. 34.
Type species, by subsequent designation, von Martens, 1870, *Cardium isocardia* Linnaeus, 1758. Recent; West Indies from Hispaniola to Trinidad, the Caribbean coast of northern South and Central America and the southern Gulf of Mexico around the Yucatán Peninsula and westward at least as far as Isla Carmen, Mexico.

Four species in the Chipola fauna have in the past (Dall, 1900; Gardner, 1926) been referred to the genus *Trachycardium.* None show the characteristic ornament of round-topped imbricating scales that are strongly developed over all, or almost all of the surfaces of the costae on the median part of the valves; hence none appear referrable to that genus *sensu stricto.* Two of the four, *"Cardium (Trachycardium)" virile* Dall and *"C. (T.)" parile* Dall, have an ornamentation that, especially posteriorly, is comprised of obliquely sloping scales along the posterior sides of the costae. This is most similar to that present on *Trachycardium belcheri* (Broderip and Sowerby), the type species of *Phlogocardia* Stewart, 1930, but the anterior ornament on the latter species is different from that found on the Chipola forms, in which it is somewhat more like that of *Trachycardium* s.s. Accordingly no subgeneric assignment of these two species is made at the present time. *"Cardium (Trachycardium)" cestum* Dall, a third Chipola species so assigned by Dall, has the general form and hinge of typical *Trachycardium* but differs in the nature of the external ornamentation and is here referred to the new subgenus *Conilocardium.* The fourth species, identified by Dall as *"Cardium" inconspicuum* Guppy, described from the Bowden beds of Jamaica, is here described as a new species, referred to *Acrosterigma* subgenus *Vasticardium* Iredale, 1927.

"TRACHYCARDIUM" VIRILE (Dall)
Plate 1, figures 3-5; Plate 10, figures 4, 5

Cardium (Trachycardium) virile DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1086; 1903, *ibid.,* v. 3, pt. 6, pl. 48, fig. 1; SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 133 [Holotype, USNM 114764; "Oligocene. Near Bailey Ferry, Calhoun County, Florida"]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 136, pl. 23, fig. 1 ["Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Calhoun County, Fla."].

Dall's detailed description of the ornamentation on this species is accurate for

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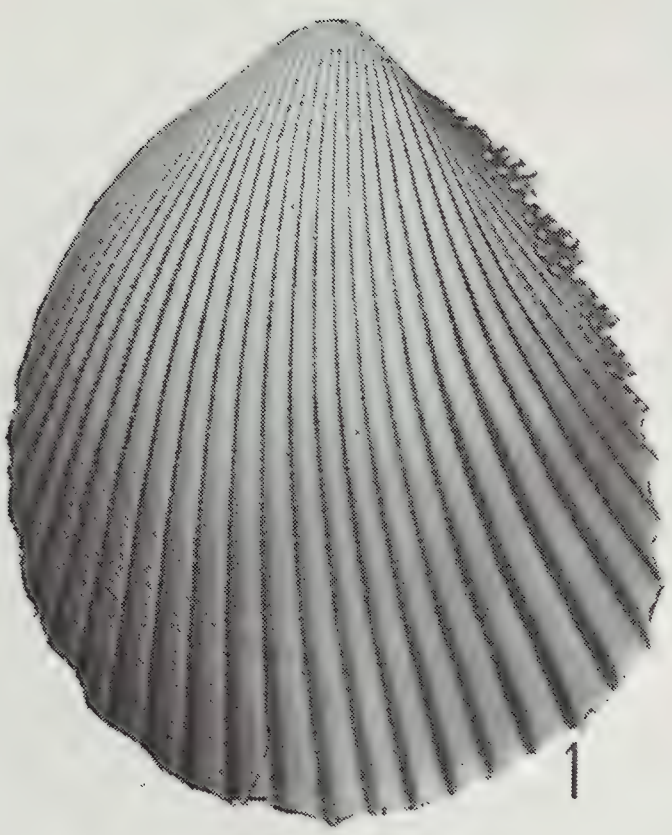
PLATE 3

Figures Page
1-5. *Acrosterigma (Vasticardium) hoerleorum* H. E. Vokes, n. sp. 162
1. Holotype, USNM 243520 (X 1); height 52.3 mm, length 44.0 mm.
Locality: TU 546, Tenmile Creek.
2. Paratype A, USNM 243521 (X 1); height 51.3 mm, length 43.6 mm.
Locality: TU 830, Tenmile Creek.
3. Paratype B, USNM 243522 (X 1.5); height 31.2 mm, length 25.2 mm, diameter (paired valves) 18.2 mm.
Locality: TU 951, Tenmile Creek.
4. Paratype C, USNM 243523 (X 1.5); height 32.7 mm, length 27.8 mm.
Locality: TU 830, Tenmile Creek.
5. Paratype D, USNM 243524 (X 1.5); height 40.5 mm, length 34.8 mm.
Locality: TU 830, Tenmile Creek.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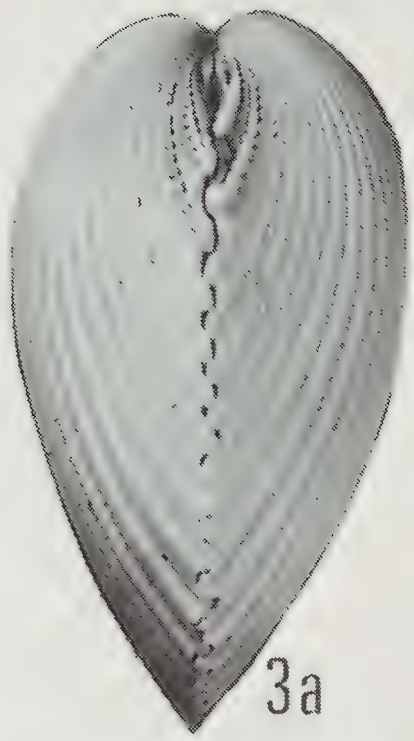
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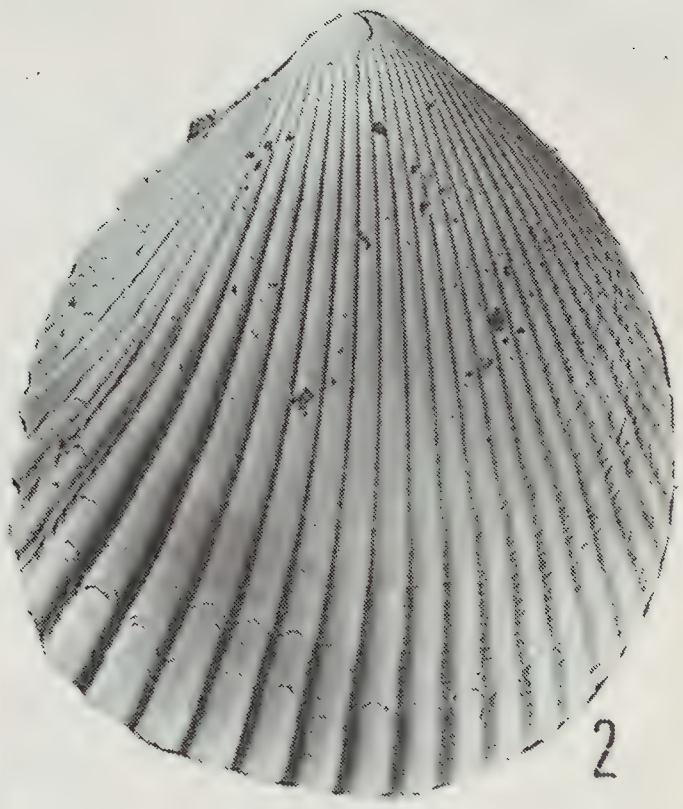
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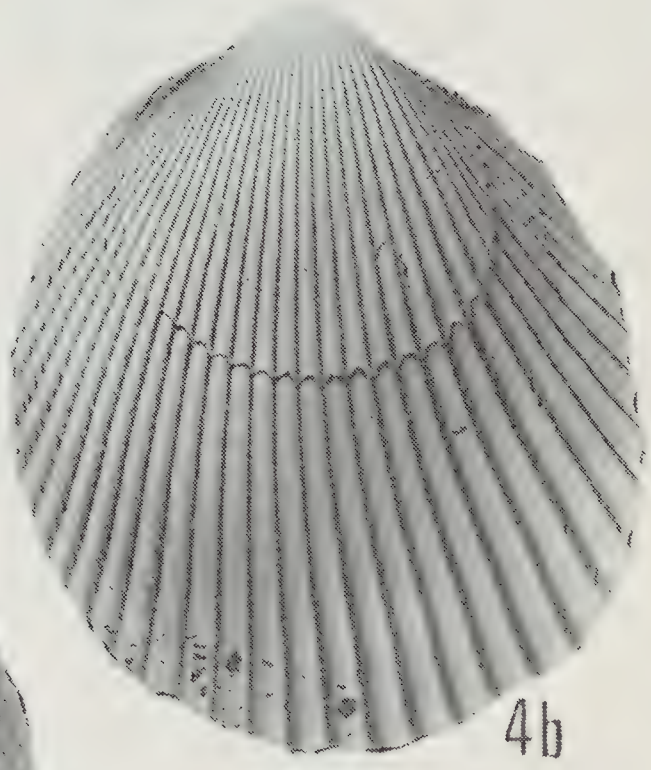
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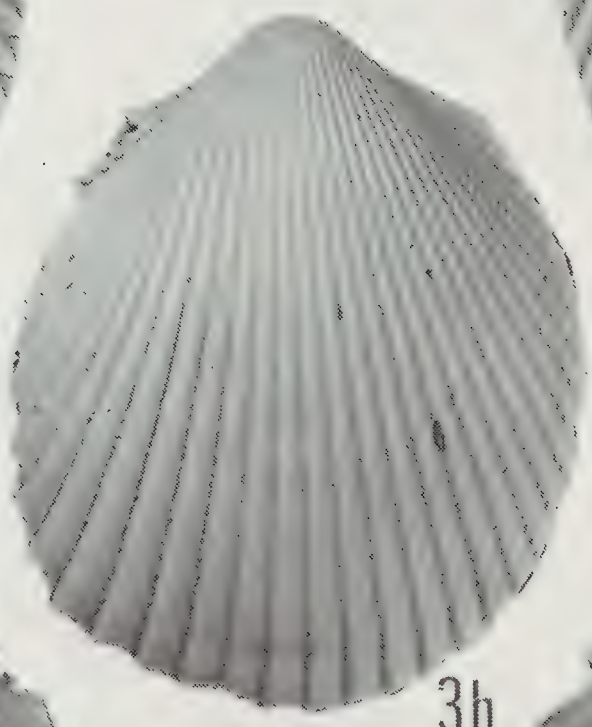
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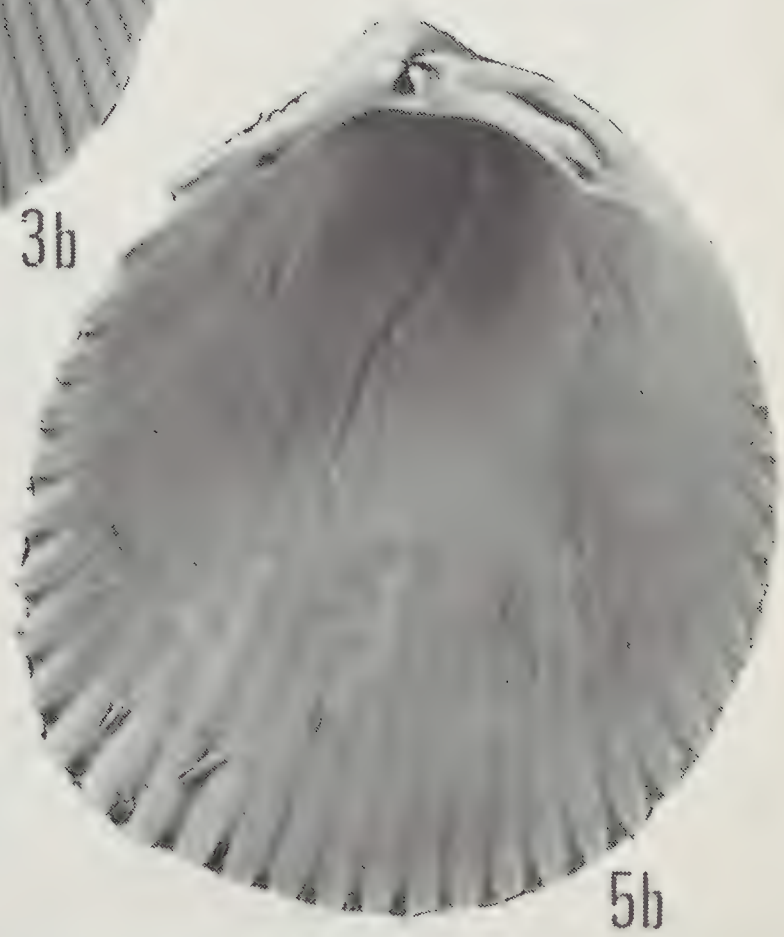
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PLATE 3

specimens the size of his type, but this feature proves to change with growth. Thus the number of anterior costae with "the strung and flattened cup-imbrication like *Cardium consors* in miniature" increases during the development, with smaller specimens such as that figured from TU 817A having but 11 ribs so ornamented, whereas the larger one from TU 961 has 16 near the margins, but with the more posterior of these showing on their upper portions the twisted oblique scales serrating the keel on the posterior side of the rib, characteristic of the costation on the main body of the valve.

The number of ribs varies from 38 to 42 with the majority having 39 or 40. One specimen (Pl. 1, fig. 4) is unique in that the three most anterior ribs of the posterior series develop oblique scalelike serrations on both anterior and posterior sides as they approach the postero-ventral margin.

"Trachycardium" virile occurs throughout the Chipola Formation but is abundant only in the lower part of the section on Tenmile Creek where there are more valves in the collection from TU 830 (260) or from TU 546 (360) than are known from all of the localities along the Chipola River and Farley Creek sections (194). The largest specimen noted in the Tulane University collections has a height of 33.0 mm, and a length of 29.1 mm. It is from locality TU 820 on Farley Creek.

Figured specimen, USNM 243509; height 30.7 mm, length 28.7 mm, diameter (left valve) 11.9 mm; locality TU 951 (Pl. 1, fig. 3).

Figured specimen, USNM 243510; height 26.4 mm, length 23.3 mm, diameter (right valve) 10.2 mm; locality TU 554 (Pl. 1, fig. 4).

Figured specimen, USNM 243511; height 19.1 mm, length 18.1 mm, diameter (left valve) 6.7 mm; locality TU 817 (Pl. 1, fig. 5).

Figured specimen, USNM 243561; height 17.8 mm, length 17.3 mm, diameter (left valve) 6.8 mm; locality TU 830 (Pl. 10, fig. 4).

Figured specimen, USNM 243562; height 22.2 mm, length 20.1 mm, diameter (left valve) 7.3 mm; locality TU 546 (Pl. 10, fig. 5).

"TRACHYCARDIUM" PARILE (Dall)

Plate 2, figures 1, 2; Plate 9, figure 7

Cardium (Trachycardium) parile DALL, 1900, Wagner Free Inst. Sci., Trans. v. 3, pt. 5, p. 1086; 1903, *ibid.,* v. 3, pt. 6, pl. 48, fig. 17; SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 131 [Holotype, USNM 114647; "Oligocene. USNM 114647; "Oligocene. Alum Bluff, Chipola River, Calhoun County, Florida"*]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 136, pl. 23, fig. 2 ["Type locality: No. 2211, lower bed, Alum Bluff, Liberty County, Fla."].

NOT *Cardium (Trachycardium) parile* Dall. DALL, 1915, U. S. Natl. Mus., Bull. 90, p. 143, pl. 4, fig. 6 [". . . Tampa silex beds at Ballast Point, Tampa Bay; . . ."]; MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 252 [Tampa reference only].

"Trachycardium" parile is one of the more easily identifiable cardiid species in the Chipola fauna being marked by the relatively low number of ribs (22 to 27, with the majority having 24 or 25) and their unusual ornament in which the surficial "projections" or "imbrications" gradually change from completely crossing the more anterior ribs to a position as "spinules" on their posterior side toward the rear of the valve. Dall's original description, however, appears to have been based upon a single specimen and the number of ribs marked by each type of ornament is subject to variation; thus the number of anterior ribs that are completely crossed by the "imbrications" varies from seven to twelve in the material here studied. Furthermore, the "four ribs next posterior [that] have on their tops slender arcuate rather sparse imbrications" have not been observed; the spacing of the imbrications being relatively constant and consistent with that of those on the more anterior ribs. Dall's statement may, in fact, reflect the fragility of this ornament, the projections being easily broken away with little evidence left of their previous occurrence.

This species was described from the lower bed at Alum Bluff where it is common to abundant. In the Tulane University collec-

*Alum Bluff is on the east bank of the Apalachicola River in Liberty County, Fla. Dall's original description located the species as ". . . the lower bed at Alum Bluff and on the Chipola River, Calhoun County, Florida." The citation above is clearly a *lapsus.*

tions from the Chipola Formation of Calhoun County it is present only in the upper half of the section and actually is most abundant in the uppermost fossiliferous strata exposed on the Chipola River. Although Gardner listed it as "present" at her locality "2213, one mile below Baileys Ferry," and as "rare" at locality "3419, McClelland farm 1 mile below Baileys Ferry," it is wholly absent in all Tulane collections from the twelve localities situated in the lower half of the section exposed along the Chipola River. In view of the fact that there seems little doubt but that some mixing of the early collections did occur (see discussion of occurrence of *Fragum tunicula,* n. sp.), it may well be that such was the basis for the record of the present species in the Bailey's Ferry area.

The Tampa Limestone specimen figured by Dall (1915, pl. 4, fig. 6) as this species seems clearly to represent some other form and is, on the whole, more reminiscent of *Acanthocardia propeciliare* than of any other Chipola species, having essentially triangular ribs with nodes on their crests and so far as can be observed, no trace of the "spinule"-like development on the posterior side of the more posterior ribs.

Figured specimen, USNM 243513; height 24.8 mm, length 23.0 mm, diameter (left valve) 10.1 mm; locality TU 547 (Pl. 2, fig. 1).

Figured specimen, USNM 243514; height 22.1 mm, length 22.0 mm, diameter (right valve) 8.8 mm; locality TU 547 (Pl. 2, fig. 2).

Figured specimen, USNM 243559; height 25.7 mm, length 23.4 mm, diameter (left valve) 9.7 mm; locality TU 555 (Pl. 9, fig. 7).

Subgenus CONILOCARDIUM, new subgenus

Type species, *Cardium (Trachycardium) cestum* Dall. Chipola Formation lower Miocene, Florida.

Diagnosis: Trachycardiids with outline and hinge that is typical of the genus, but differing strikingly in the nature of the external ornamentation. In typical *Trachycardium* the surface is marked by radial ribs that are round-topped, moderately wide and separated by interspaces of approximately equal width, with the tops of each rib being well-covered by heavy, more or less imbricating, arched scales that, on the median and posterior areas of the valve, are prolonged down along the posterior side of the rib until they tend to abut against the next succeeding one. The anterior limb of each scale is shorter than the posterior, resulting in a rather decided posterior "slant" to the top of the individual scale. The anterior costae are marked by essentially symmetrical, thickened and almost bead-like scales that on the anteriormost eight or nine ribs show no tendency toward a posterior prolongation.

In contrast, the ribbing on Dall's *"Cardium (Trachycardium)" cestum* is, on the anterior and median parts of the valve surface, essentially triangular in section (text fig. 1) with the triangles capped by an elevated keel, which in turn is surmounted by relatively distant transverse bead-like imbrications. On the main body of the valve these "beads" cross the crest of the keel and tend to extend down almost equally on the upper part of its anterior and posterior sides resulting in the "T-rail" shape described by Dall. Those on the more anterior ribs tend to extend down along the anterior side of the keel, but not on its posterior side, although they are higher posteriorly than anteriorly and, as expressed by Dall in his original description, appear as if "pressed over backward" to overhang the interspaces. The sides of these anterior and median costae are pustulose, with relatively numerous small, dust-like pustules that are arranged in more or less curved rows trending from the bottom of the interspace up the sides of the costae, the arch of the trend being toward the umbo.

The posterior portion of the valve surface has a markedly different ornament. The margin of the valve in this region is deeply serrate with the crests of the serrations marking the centers of the costae and with the raised edges forming a sort of double keel, one side of which marks the anterior edge of the rib-crest, the other the posterior edge and with a distinctly depressed area between them. This condition is most strongly developed on the more anteriorly located costae of the posterior series, but the anterior segment soon weakens and

Text figure 1. Diagrammatic section showing profile of the radial ribbing of *Trachycardium (Conilocardium) cestum* (Dall).

becomes little more than a slightly raised ridge bordering the linear interspace area, while the posterior segment becomes strengthened and tends to project somewhat anteriorly to overhang the median rib crest. The ornamentation on the posterior element of the rib keels consists of diagonally trending, raised beads with an anterior side that is distinctly above the summit; these "beads" do not extend down the sides of the keel. The anterior keel segment is usually smooth and non-ornamented; one specimen has been noted, however, in which the anteriormost costa had beading similar to that of the posterior segment. Interspaces and sides of the costae in this area lack the pustulose ornamentation that is so characteristic of the more anterior areas and tend to show only somewhat irregularly-developed growth lamellae.

TRACHYCARDIUM (CONILOCARDIUM) CESTUM (Dall)

Plate 2, figures 3-7; Plate 9, figure 1;
Text figure 1

Cardium (Trachycardium) cestum DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1083; 1903, *ibid.*, v. 3, pt. 6, pl. 48, fig. 14; SCHUCHERT *et al.*, 1905, U. S. Natl. Mus., Bull. 53, p. 128 [Holotype, USNM 114757; "Oligocene. Chipola River, Calhoun County, Florida"]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 133, pl. 22, fig. 8 ["Cotypes: U. S. Nat. Mus. No. 114757. Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla."].

NOT *Cardium (Trachycardium) cestum* Dall. DALL, 1915, U. S. Natl. Mus., Bull. 90, p. 142, pl. 4, fig. 13 ["Tampa silex beds, at Ballast Point, Tampa Bay . . ."] = *(Cardium (Trachycardium) delphicum ballastum* Mansfield, 1937.

Trachycardium (Conilocardium) cestum is widely disseminated in the Chipola fauna, occurring at 48 of the 58 localities from which collections have been made and present in all recognizable facies in the typical area, although apparently absent from the lower bed at Alum Bluff. Some variation of possible ecologic significance may be observed in the counts of the number of costae present on specimens from different horizons or areas of Chipola exposure. Dall, in his original description, cited the number as 34; however, a count of 200 specimens shows a variation between 28 and 35, with 154 of the total falling within the 31 to 33 range, (56 specimens with 31, 57 with 32 and 41 with 33 costae). When we compare the number of ribs on 40 specimens from the lower beds on the Chipola River with those of a similar number from the lower strata exposed on Tenmile Creek, we find that 17 of the 40 from the Chipola River show 33 costae while only three from the Tenmile Creek area have this number. Sixteen of those from the latter area have 31 ribs. As is noted elsewhere in the present paper, this is but one aspect of the faunal

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PLATE 4

Figures — Page

1-3. *Papyridea multicostula* H. E. Vokes, n. sp. 169

1. Holotype, USNM 243525 (X 1.5); height 25.4 mm, length 31.8 mm.
Locality: TU 548, Chipola River.

2. Paratype A, USNM 243526 (X 1.5); height 25.4 mm, length 31.6 mm.
Locality: TU 458, Chipola River.

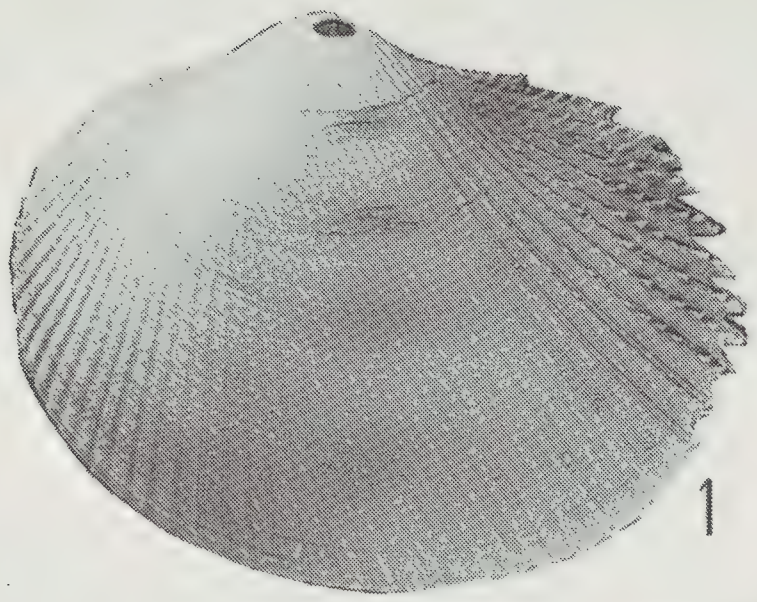
3. Paratype B, USNM 243527 (X 4); height 17.5 mm, length 23.7 mm.
Locality: TU 458, Chipola River.

3a. Oblique view of anterior end; note abundant papillose granulations posteriorly that give way to beads on the most anterior ribs. 3b. Oblique view of posterior end of valve; note the development of median groove on ribs of posterior series.

4. *Papyridea bulbosa* (Dall) 165

Figured specimen, USNM 243528; height 23.5 mm, length 27.6 mm.
Locality: TU 458, Chipola River.

4a. Lateral view of valve (X 1.5). 4b. Oblique view (X 4) of ornamentation on median surface of more posterior ribs that appear to gradually strengthen to the transverse beads of the anterior-most ribs. 4c. Oblique view (X 4) of posterior end of valve showing progressive change in rib shape and ornamentation.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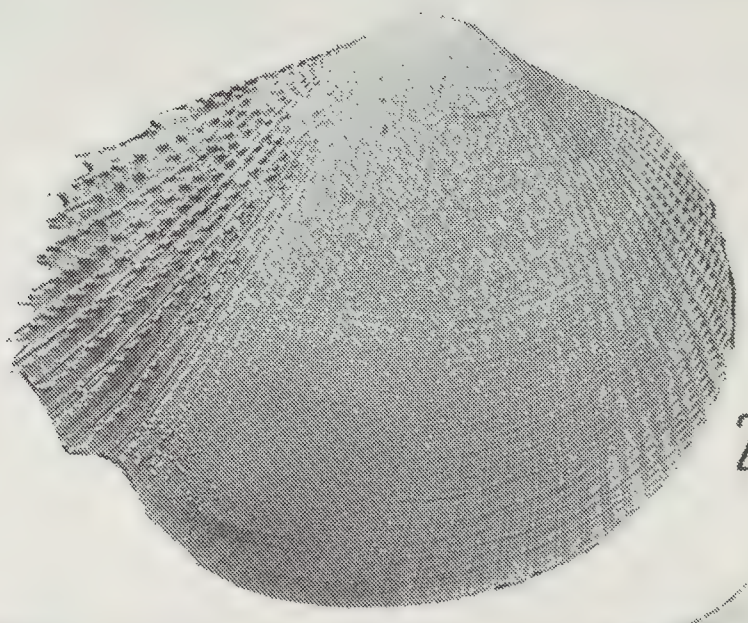
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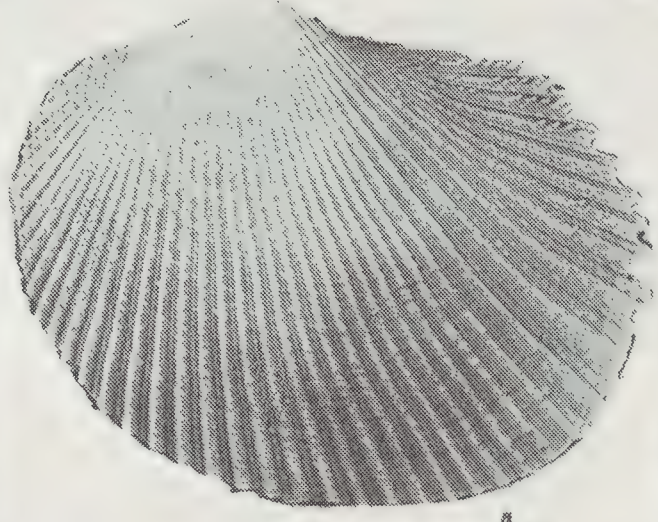
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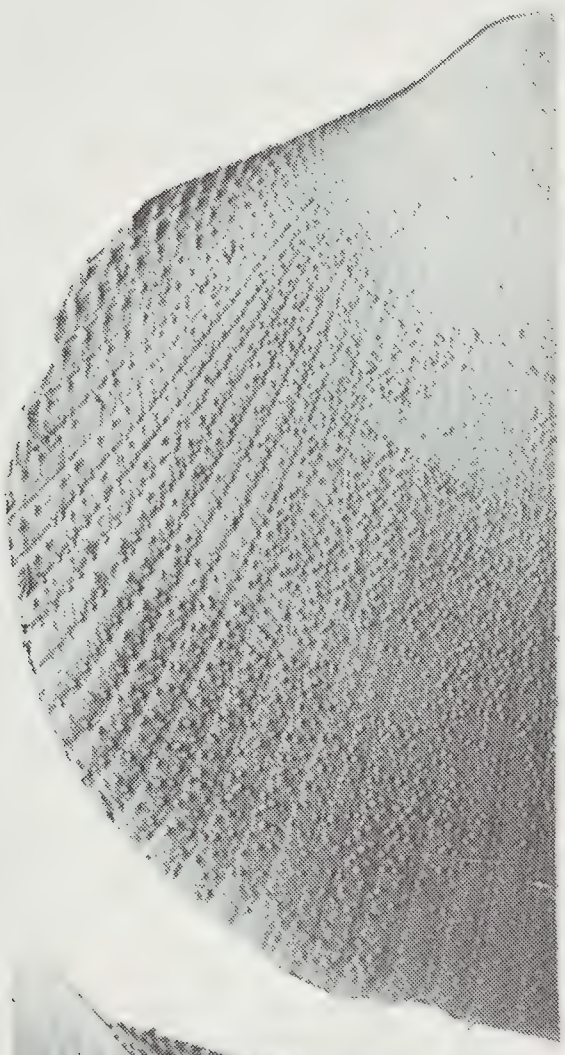
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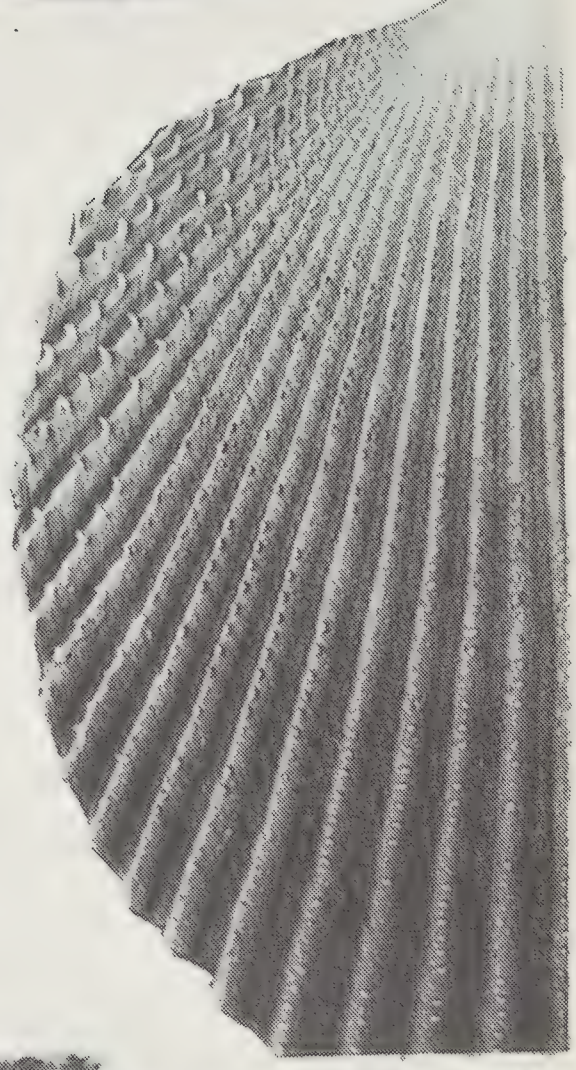
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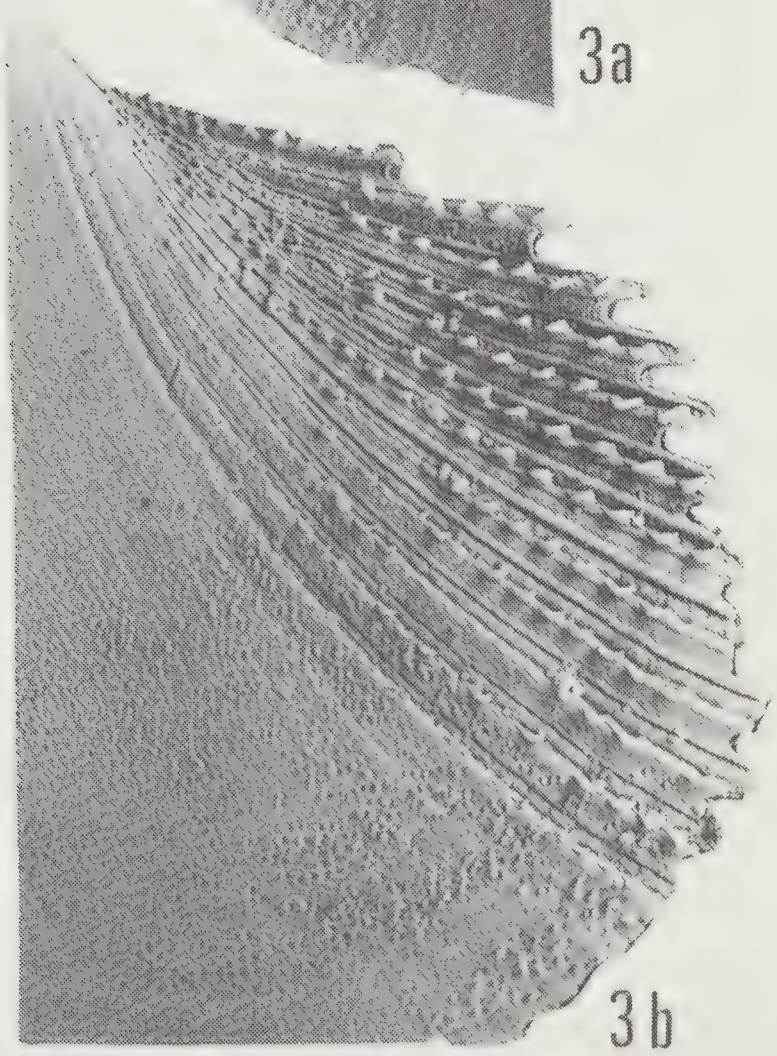
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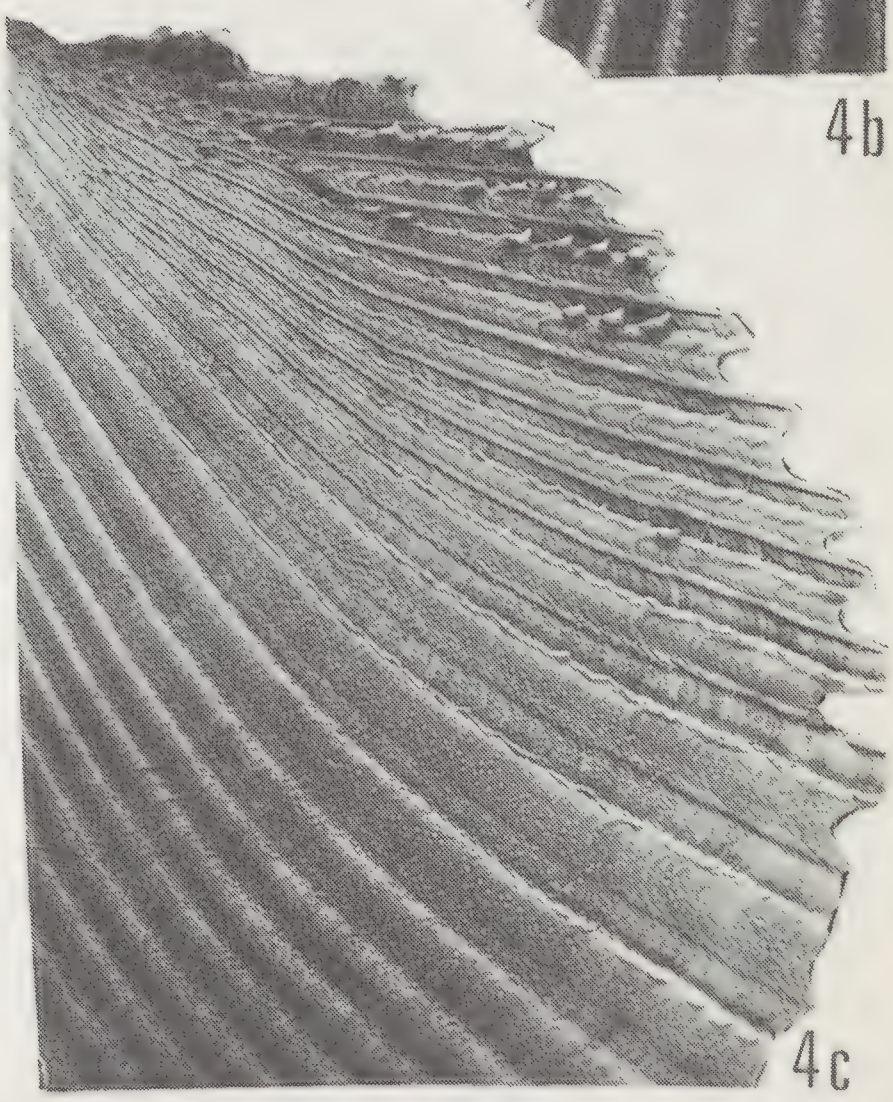
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PLATE 4

differences that mark the basal beds at these two, relatively close, exposed sections.

This is the largest form of *Trachycardium* in the Chipola fauna. One right valve in the collections from locality TU 950 has a height of 54.8 mm, a length of 42.8 mm with a diameter of 20.6 mm. This individual valve is the largest Chipola cardiid in the Tulane University collections, but is exceeded in size by the specimen of *Agnocardia acrocome* in the Hoerle Collection cited in the discussion of that species.

Figured specimen, USNM 243515; height 42.0 mm, length 36.2 mm, diameter (right valve) 15.7 mm; locality TU 458 (Pl. 2, fig. 3).

Figured specimen, USNM 243516; height 47.5 mm, length 36.8 mm, diameter (right valve) 17.8 mm; locality TU 555 (Pl. 2, fig. 4).

Figured specimen, USNM 243517; height 35.0 mm, length 29.9 mm, diameter (left valve) 13.2 mm; locality TU 458 (Pl. 2, fig. 5).

Figured specimen, USNM 243518; height 27.1 mm, length 24.6 mm, diameter (paired valves) 21.0 mm; locality TU 458. (Pl. 2, fig. 6).

Figured specimen, USNM 243519; height 42.5 mm, length 34.0 mm, diameter (right valve) 15.6 mm; locality TU 458 (Pl. 2, fig. 7).

Figured specimen, USNM 243550; height 38.7 mm, length 33.2 mm, diameter (right valve) 13.3 mm; locality TU 458 (Pl. 9, fig. 1a).

Figured specimen, USNM 243551; height 48.5 mm, length 38.2 mm, diameter (right valve) 17.9 mm; locality TU 555 (Pl. 9, fig. 1b).

Genus ACROSTERIGMA Dall, 1900

Acrosterigma DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, pp. 1073, 1090.

Type species, by original designation, *Cardium dalli* Heilprin. Pliocene; Florida.

Dall distinguished *Acrosterigma* as a "Section" of the genus *Trachycardium* on the basis of the "elevated mesial rib internally, radiating from the umbonal cavity" that is usually present in *Cardium dalli* Heilprin (1887, p. 131, pl. 16a, fig. 70). As observed by Stewart (1930, p. 265), however, the ridge is variable in development and "the Academy has one large specimen (length *ca.* 13 cm) on which it is absent from the left valve and very small in the right valve." It is also absent on one relatively immature (height 48 mm) specimen of the almost 100 in the Tulane collections. Stewart concluded (p. 266); "This ridge therefore is considered of no systematic value."

The nature of the hinge and ornamentation, nevertheless, does appear to be distinctive and diagnostic. In the type species the hinge-line is strongly bent in the area of the cardinal teeth so that a line connecting these with the anterior and posterior laterals forms an angle of 115 to 120 degrees with, as noted by Stewart, the large anterior lateral a little more distant from the cardinals than is the the posterior one. The manner in which the low, broadly rounded, almost flat median radial ribs overhang the deeply channelled interspaces to the extent that, in immature specimens they almost completely roof over them to form narrow inter-costal tunnels is a distinctive feature. Further, these median costae are finely beaded on both lateral margins, but not on their tops, even on the anterior ribs. The more posterior costae are beaded on their posterior side only with the beads being somewhat stronger and more erect than are those on the median and anterior costae.

Subgenus VASTICARDIUM Iredale, 1927

Vasticardium IREDALE, 1927, Rec. Australian Mus., v. 16, no. 1, pp. 75-6.

Type species, by original designation, *Cochlea nebulosa* Martyn, 1786 [non-binomial, I.C.Z.N. Opinion 456] + *Cardium elongatum* "Bruguière" Reeve, [= *Cardium elongatum* Bruguière, 1789]. Recent, Indo-Pacific seas.

There is considerable uncertainty as to the correct name to be applied to the type species of *Vasticardium.* Iredale identified "A magnificent cockle measuring 137.5 mm in length" from Vanikoro as *V. nebulosum* (Martyn) with reference to the *Universal Conchologist* v. 2, 1786, pl. 140, adding that "the figure given by Reeve [1844, pl. 9, fig. 46] of *Cardium elongatum* Bruguière refers to this species." The International Commission on Zoological Nomenclature in Opinion

456, published March, 1957, rejected the names proposed by Martyn in *The Universal Conchologist* because that author failed to apply consistently the principles of binomial nomenclature.

The problem as to the correct substitute name to be used stems from the fact that Bruguière added to his very detailed original description of *Cardium elongatum* (1789, p. 228) references to six illustrations including three from Lister, Born, and Martini and Chemnitz that were based upon specimens said to have come from Jamaica. The Lister and Born figures had been cited previously by Gmelin (1791, p. 3250) in reference to *Cardium magnum* Linnaeus. Keen (1937, p. 22) and subsequent authors have tended to stress this feature, Keen stating that "*Cardium elongatum* Bruguière, 1792, is based upon the same figures as *C. leucostomum* Born, 1778; its type locality is Jamaica, so that Reeve's use of the name for an Indo-Pacific species is obviously untenable." Not only did this overlook the fact that among the other figures cited were some from non-Jamaican localities, but more importantly, the fact that Bruguière based his description upon actual specimens at hand rather than upon any published illustration. Bruguière clearly stated (freely translated):

> This species is remarkable for its large size, for its elongate form and for the number of ribs with which it is ornamented; *the shell of which I give the description* [italics mine] is not the largest; there are in the collections those which surpass it by almost twice the length and with the other dimensions in proportion; it is "trois pouces sept lignes" [about 80 mm] in length, "deux pouces sept lignes" [about 62 mm] wide and "deux pouces quatres lignes" [58 mm] in depth. The shape is an elongate oval with the sides almost equal; each valve is ornamented exteriorly by 39 or 40 longitudinal ribs separated by narrower squared interspaces. The first dozen ribs are ornamented on their convexity by very small, granular tubercles, especially those close to the ligament [Bruguière clearly used an orientation of the valves that is the reverse of that presently accepted]. The median ribs are square and marked on each side by projecting striae that crenulate them; the fifteen most posterior ribs are a little more rounded, closer together than the previous ones and marked along their length by elevated striations that are lying one above the other from top to bottom, that is to say, with the edges towards the top.
>
> The region of the lunule is lanceolate, flat, lamellar, six lines long, three and a half wide, reddish. I have counted 37 deep crenulations of conical shape on the interior of the margins of each valve; those in front are more separated, more oblique than the others and of a flesh-colored tint; those which come after are equal, except above in the region of the lunule, where they have a little more depth than the others; these are fitted exactly the one into the other and leave only a small gap between on the anterior face. The interior of the valves is white . . .
>
> *Du cabinet de M. le chevalier de la Marck.* [italics of Bruguière]

The writer's personal collections made in the Philippine Islands in 1952-53 contain three complete specimens plus two isolated valves that agree well with the above description. All have 39 or 40 ribs with 37 or 38 internal marginal crenulations differing primarily in the fact that the more fresh specimens show a distinctly pinkish-brown tint along the crenulated posterior margin, the "flesh-color" noted by Bruguière. Also, the number of tuberculated posterior costae tends to vary between 7 and 9 rather than 12. The writer agrees with Clench and Smith when they state (1944, p. 7) that "Bruguière's *T. [Trachycardium] elongatum* was probably based upon an East Indian specimen. *T. magnum* and *T. elongatum* are exceedingly close, the differences being very slight indeed. . . . Bruguière pointed out that *T. elongatum* possesses 39 to 40 ribs, while *T. magnum* generally has 32 to 35. However, we possess specimens of *T. magnum* showing a variation in the number of ribs, one specimen having 40 ribs, two specimens with 38 while all others have less than 36 ribs. We believe that this variation in the number of ribs has been responsible for most of the confusion which has existed."

The Chipola species mis-identified by Dall (1900, p. 1082) as *"Cardium" inconspicuum* Guppy, a Bowden form from Jamaica, has the anterior costae marked by transversely "shingled" cross-ridges similar to the "elevated striations . . . lying one above the other from top to bottom" of the species of Bruguière; the posterior costae are marked by granular tubercles that are most numerous and strongly developed adjacent to the ligament, and the posterior margin is notch-

ed by the projecting ends of the costae. Under ultra-violet light this crenulated margin reveals a pattern indicative of its having been strongly colored during life, as in the modern *Vasticardium elongatum.*

ACROSTERIGMA (VASTICARDIUM) HOERLEORUM H. E. Vokes, n. sp.

Plate 3, figures 1-5; Plate 10, figure 2

Cardium (Trachycardium) inconspicuum Guppy. DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1082 [in part, Chipola reference only; not *Cardium inconspicuum* Guppy, 1886, "Miocene of Jamaica"]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 137.

Acrosterigma inconspicuum Guppy. STEWART, 1930, Acad. Nat. Sci. Phila., Spec. Publ. 3, p. 137 [reference to Gardner, 1926].

Diagnosis: Shell of medium size, subequilateral, broadly subovate, with the anterior and antero-ventral margins broadly and almost equally rounded, straightening out somewhat along the median and postero-ventral region to the rather sharply arched postero-ventral "corner," above which the posterior margin is curved to a degree almost equal to that of the anterior end; umbones narrow, moderately high, not strongly inflated. Ornamentation consisting of rather low radial ribs, 32 to 37 in number, separated by narrower interspaces; ribs on the anterior and median areas of the valve broad, slightly rounded above, with shallow, round-bottomed interspaces the bottoms of which are a little less than one-half as wide as the more flattened upper surface of the intervening costae; on well-preserved specimens the first three ribs smooth and the next anterior 11 to 13 marked by raised, scalelike growth lamellae that reflect the slight denticulation of the anterior margin and thus are slightly arcuate dorsally on the crest of the ribs; the number of ribs so ornamented increasing from but three or four in the earliest stages observed with the remaining costae on the anterior and median surface having smooth tops but the lateral slopes and interspaces crenulated by raised growth lamellae. Interspaces between the first three ribs immediately behind the postero-ventral "corner" distinguished by the development of a low, rounded inter-rib, which is absent elsewhere on the valve. The posterior slope marked by seven or eight flattened costae, the two most dorsal being rather narrow and raised, with relatively strong elongately curved beads on their crests; the next succeeding ribs low, flattened and wide, with narrow, almost linear interspaces; these ribs tending to have slender scalelike beads on their antero-posterior sides that extend into the interspace area. (These beads apparently are easily broken or eroded off, often being preserved only on one or two of the five or six ribs on which they may be observed in unusually well-preserved specimens.)

Holotype, USNM 243520; height 52.3 mm, length 44.0 mm, diameter (left valve) 13.2 mm; locality TU 546 (Pl. 3, fig. 1).

Paratype A, USNM 243521; height 51.3 mm, length 43.6 mm, diameter (right valve) 13.3 mm; locality TU 830 (Pl. 3, fig. 2).

Paratype B, USNM 243522; height 31.2 mm, length 25.2 mm, diameter (paired valves) 18.2 mm; locality TU 951 (Pl. 3, fig. 3).

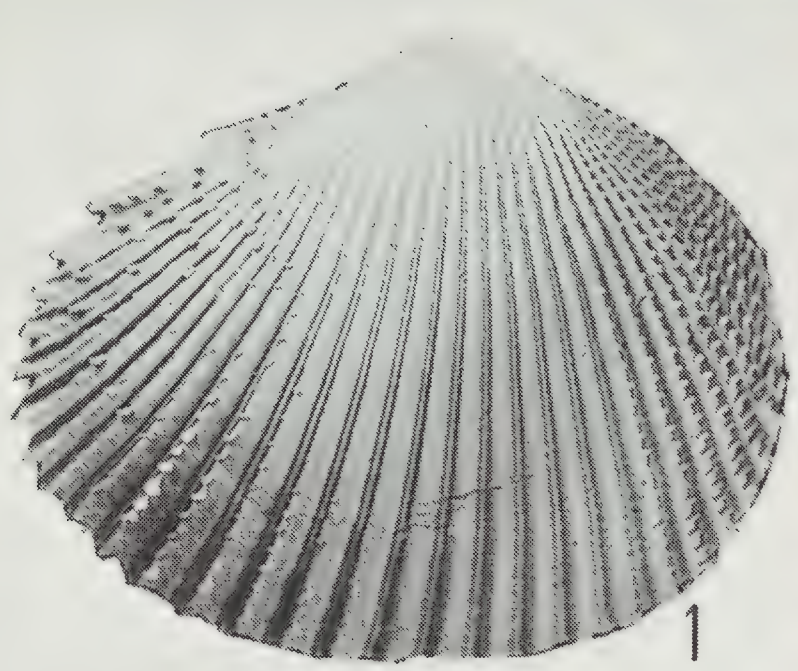
Paratype C, USNM 243523; height 32.7 mm, length 27.8 mm, diameter (left valve) 9.0 mm; locality TU 830 (Pl. 3, fig. 4).

PLATE 5

Figures Page

1-4. *Papyridea miocica* H. E. Vokes, n. sp. 168

1. Paratype A, USNM 243529 (X 1.5); height 27.6 mm, length 35.1 mm. Lateral view of specimen from coral facies.
   Locality: TU 547, Chipola River.
2. Holotype, USNM 243530 (X 1.5); height 28.3 mm, length 39.2 mm.
   Locality: TU 825, Farley Creek.
3. Paratype B, USNM 243531; height 26.5 mm, length 33.3 mm. Specimen from coral facies.
   Locality: TU 547, Chipola River.
   3a. Oblique view (X 4) of anterior end of valve showing strong transverse beading of ribs. 3b. Oblique view (X 4) of posterior end of valve showing development of curved, scalelike spines on posterior side of costae only, and the deep median groove on most posterior ribs. 3c. Lateral view (X 1.5).
4. Paratype C, USNM 243532 (X 1.5); height 19.9 mm, length 27.4 mm.
   Locality: TU 825, Farley Creek.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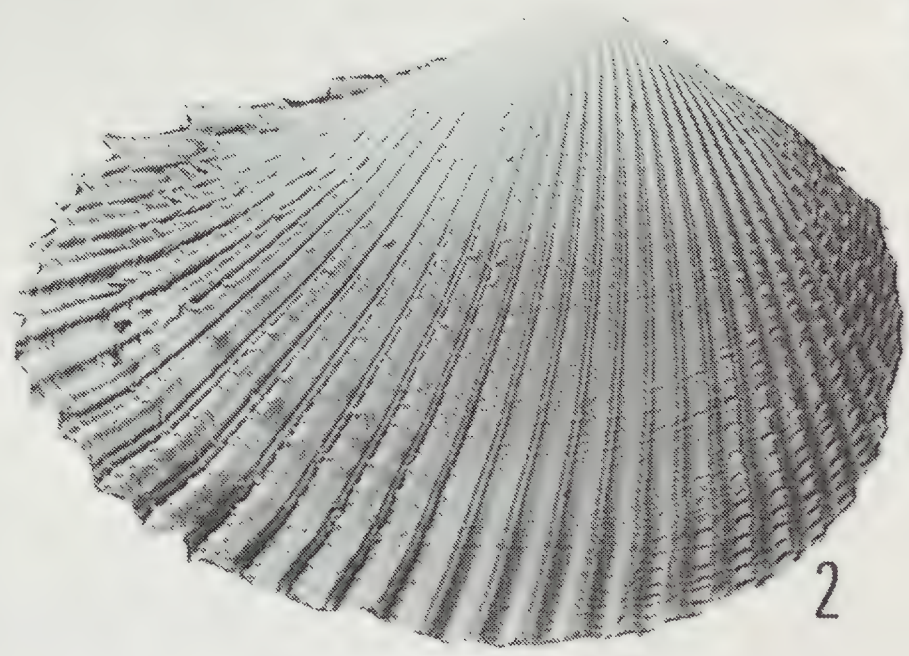
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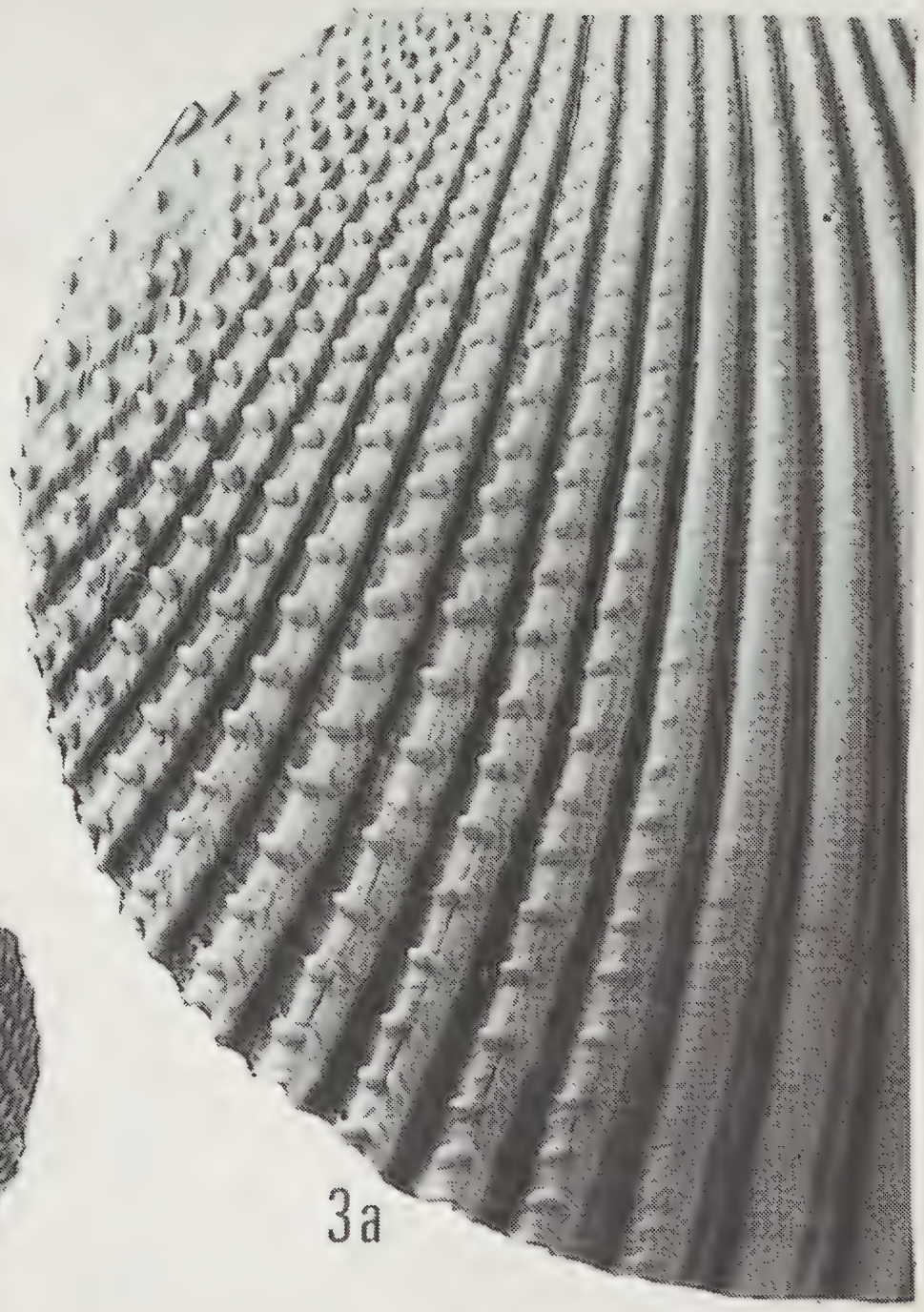
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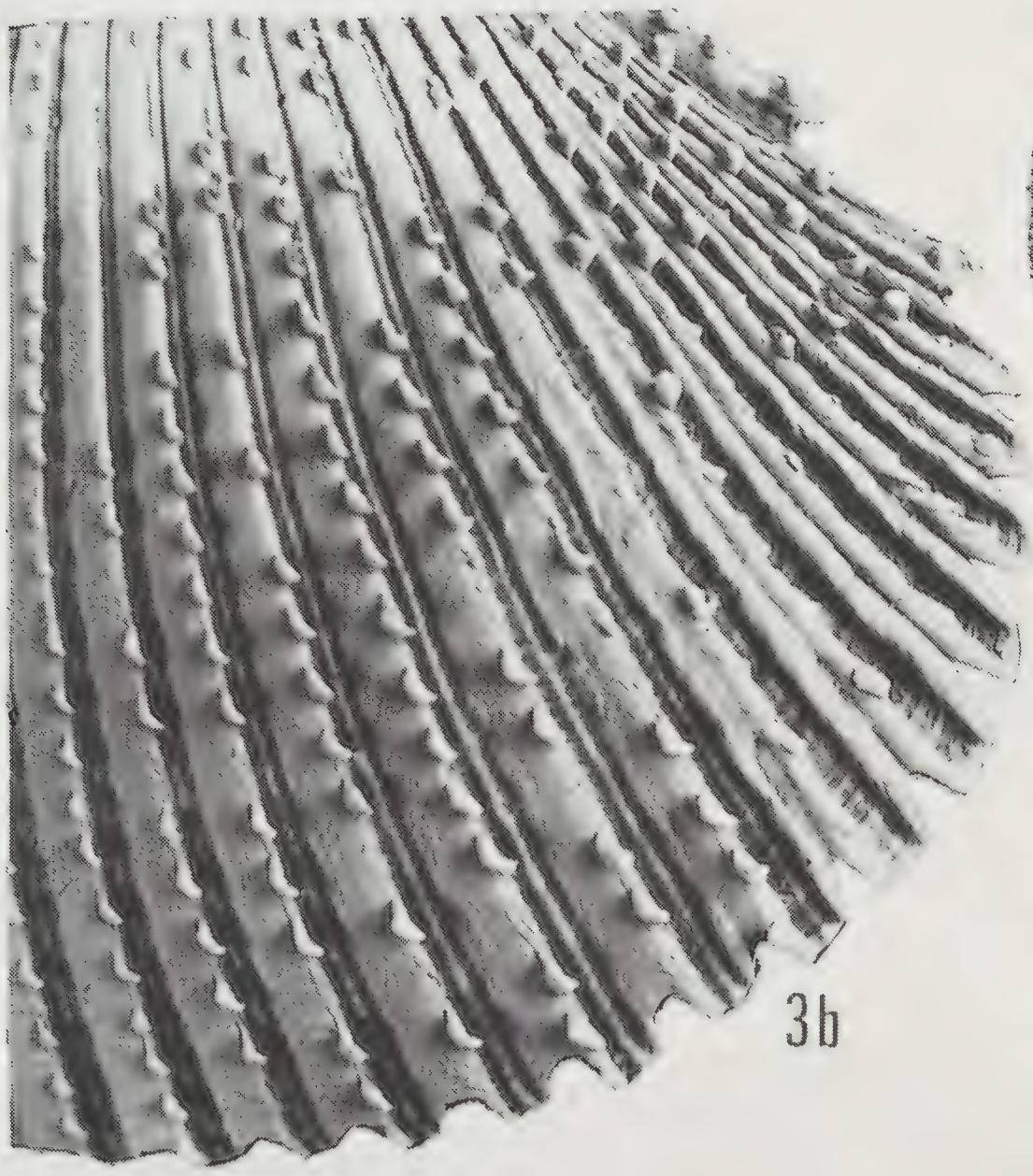
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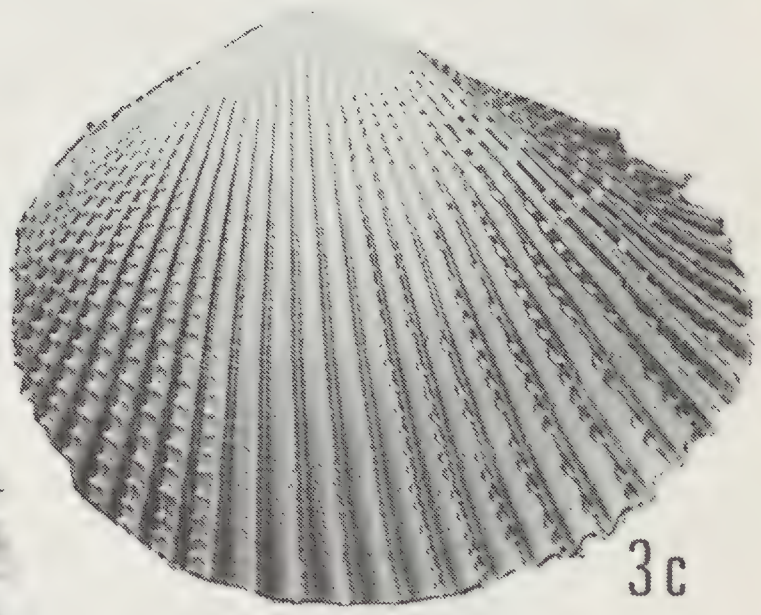
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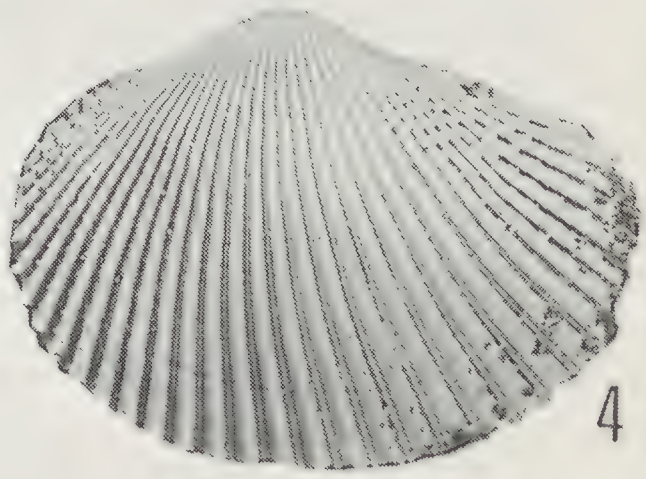
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PLATE 5

Paratype D, USNM 243524; height 40.5 mm, length 34.8 mm, diameter (left valve) 11.0 mm; locality TU 830 (Pl. 3, fig. 5).

Paratype E, USNM 243560; height 45.9 mm, length 38.4 mm, diameter (right valve) 12.5 mm; locality TU 830 (Pl. 10, fig. 2).

The largest specimen in the collections, an incomplete right valve from TU 830, has a height of 60.5 mm, and a diameter of about 14 mm.

Discussion: Neither Dall nor Gardner figured the Chipola form that they identified as *Cardium inconspicuum* Guppy, a species described from the "Miocene" of Jamaica and reported from the fauna of the Bowden Formation by Woodring (1925, p. 138, pl. 19, figs. 1, 2), who added (p. 139): "A worn broken valve from the Chipola formation called *C. inconspicuum* has narrower ribs and wider interspaces." According to Woodring, the typical Bowden form has 40 to 41 ribs with only the 10 to 13 anterior ribs "ornamented by transverse or slightly oblique" beads. The Chipola specimens have 32 to 37 ribs, the majority having 34 or 35 (based upon a count of 25 specimens); of these the anterior 15 or 16 show transverse, bead-like ornamentation. *"Cardium (Trachycardium)" waylandi* Woodring (1925, p. 139, pl. 19, figs. 3, 4), also from the Bowden fauna, is similar in shape and number of costae, but it differs in details of ornamentation, primarily in that the ribs tend to be flat-topped and to overhang the narrow, deeply channeled interspaces. *"Cardium (Trachycardium)" linguatigris* Maury (1917, p. 373 [209], pl. 62 [136], fig. 2) appears to be the Dominican Miocene analogue of *A. hoerleorum,* but it differs in having 42 costae.

The recent Panamic-Pacific species *"Cardium (Trachycardium)" pristipleura* Dall, 1901 (p. 389) [= *Cardium maculosum* Sowerby. 1833 (non Wood, 1815) + *C. maculatum* Sowerby, 1840 (non Gmelin, 1791), + *C. hornelli* Tomlin, 1928] also is to be referred to *Acrosterigma (Vasticardium).* According to Keen (1971, p. 153) it has 34 to 39 ribs; hence it appears possible that it is a paciphile descendant of *A. (V.) hoerleorum,* n. sp., which has 32 to 37 ribs.

It gives much pleasure to dedicate this species to Mr. and Mrs. R. C. Hoerle (Bob and Shirley) of West Palm Beach, Florida, with whom we have spent many pleasant and productive days collecting and discussing the Chipola fauna.

Genus PAPYRIDEA Swainson, 1840

Papyridea SWAINSON, 1840, Treatise on Malacology, p. 374.

Type species, by subsequent designation, Gray, 1847 [November], *Cardium soleniforme* Bruguière, 1789. Recent; Cape Hatteras to southern Brazil.

Swainson included four species in his cardiid "subgenus" *Papyridea* but did not cite their authors:

> *"P. Soleniforme.* Wood, Conch., pl. 56, f. 3.
> *apertum.* Ib. 56, f. 2.
> *transversum.* Sow. Conch. f. 4
> *ringens.* Wood, pl. 53, f. 1, 2."

Wood's *Index Testaceologicus* (1828, p. 27) (I do not have present access to his *General Conchology)* also cites no author for the species *soleniforme,* but lists among others the references to Lister, Gualtieri, and Martini and Chemnitz that are also cited by Bruguiere (1789, p. 235) in describing his *soleniforme,* plus the illustrations given in the *Tableau Encyclopédique et Méthodique* (1798, pl. 296, figs. 6a, b). He also added "Gm. 3226 [*S. bullatus*]" wherein Gmelin gives the same Lister, Gualtieri, and Martini and Chemnitz references, plus two that are cited with question; these are to Knorr and to Rumphius "mus. t. 44, f. N ?". This latter was the sole reference cited by Linnaeus in 1758 (sp. 31, p. 673) for the original description of his *"Solen bullatus."* This is a very poor figure and cannot certainly be identified, Dall's (1900, p. 1106) suggestion that it represents an arcid species being as good a guess an any. Herrmannsen (1847 [Sept. 8], p. 200) cited, as the type of *Papyridea, "Card. bullatum L."* an obvious reference to the *"Solen" bullatum,* presumably of the Gmelin edition of the *Systema Naturae,* but this cannot be accepted since

Linnaeus never described a "*Cardium bullatum.*" Gray's designation two months later, of *soleniforme* is the oldest valid one with which I am acquainted.

This species was identified for many years as *spinosum* Meuschen, 1787, following Dall (1900, p. 1106), but that name had been used the year before by Lightfoot in the *Portland Catalogue;* accordingly Clench and Smith (1944, pp. 16, 17) applied the name *hiatus* Meuschen, overlooking the fact that the Meuschen names in the *Museum Geversianum* were not consistently binomial and hence not nomenclatorially available.

PAPYRIDEA BULBOSA (Dall)
Plate 4, figure 4; Plate 9, figure 4

Cardium (Papyridea) bulbosum DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1109; 1903, *ibid.,* v. 3, pt. 6, pl. 48, fig. 20; SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 128 [Holotype, 114762; "Oligocene, Chipola River, Florida"]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 142, pl. 23, fig. 17 ["Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla."].

As noted by Gardner, the original description was based upon a single individual; examination of a larger number of specimens indicates that there is a considerable degree of variation in the number of radials (see Table 4) and that Dall's counts of 9 anterior, 16 medial and 13 posterior = 38 ribs, are too precise to define the species. Counts of the ribbing on 23 specimens in the Tulane University collections show a variation between 37 and 44 in total number of ribs and between 12 and 14 in the number on the posterior area. The distribution of the counts as to total number of radial ribs seems to suggest variability without any tendency to a precise maxima; the number of radials on the posterior area, however, clearly indicates that 13 is the normal complement.

There is much variation in the nature of the ribs, also. Dall described those on the posterior end as being obliquely flattened, with their highest part on the posterior side and the last three or four bearing minute spiny pustules. Well-preserved specimens show that the most anterior one or two of

TABLE 4

Species:	Number of radial ribs: 32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	Number of specimens counted:
A.																			9	50	51	52	53	54	
P. miocica	4	7	14	15	21	14	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	80
P. bulbosa	—	—	—	—	—	3	4	4	3	4	2	2	1	—	—	—	—	—	—	—	—	—	—	23
P. multicostula	—	—	—	—	—	—	—	—	—	—	—	1	5	11	11	6	9	9	9	9	5	4	1	80

Species:	Number of posterior radials: 9	10	11	12	13	14	15	16	17	18	Number of specimens counted:
B.											Number of radial ribs on Chipola species of *Papyridea:*
P. miocica	—	—	—	—	1	1	5	31	11	1	A. Total number of ribs.
P. bulbosa	—	—	—	5	16	2	—	—	—	—	B. Number on posterior area only.
P. multicostula	1	3	20	23	3	—	—	—	—	—	

the ribs is obliquely flattened; the immediately succeeding rib tends to have a shallow, rather indistinct groove that progressively becomes more strongly developed on the more posterior ribs until in some forms it has completely divided them (Pl. 4, fig. 4c). The anterior portion of each rib is "pushed" laterally until it is so adjacent to the posterior segment of the preceding radial as to limit the intervening interspace to a narrow grooved line. The "spiny pustules," which are better described as small, curved, platy spines, may be present to greater or less degree on all of the posterior ribs. In general they are more numerous and strongly developed on the more posterior ribs where they are always present only on the segment posterior to the median "groove." They tend to be weak and present only on the extreme posterior apex of the obliquely flattened, anteriorly located ribs of this series, and seem to have thus been particularly exposed to wear and breakage, being almost always absent on specimens from localities of more coarse-grained matrix, and but sparsely preserved on those from the finer-grained sites.

Ribbing on the median portion of the valve immediately in front of the posterior series is marked by being rather lower and rounded with interspaces that are approximately two-thirds as wide. The demarcation between the ribs and the interspaces is sharp, almost grooved. This results in the interspaces appearing as if marked by a low, broad interrib. Anteriorly the median costae become progressively more triangular in profile; then near the anterior end there develops a series of ribs that are more-or-less the image of the posterior set in that they become obliquely flattened with the highest part on the anterior side and bear curved, platy spines on the crest and anterior slope (Pl. 4, fig. 4b). Well-preserved specimens show that the entire surface of the valve between third or fourth most anterior and posterior radials is covered with minute granular pustules that usually are more numerous in the interspace areas but which tend to be somewhat stronger, more prominent, and often aligned along the crests of the more anterior of the costae on the median area of the valve. This feature emphasizes the rather gradual transition from the median to the anterior ribbing, and being often eroded away in specimens from more coarse matrix localities, makes impossible any statement as to the range of variation in the numbers of

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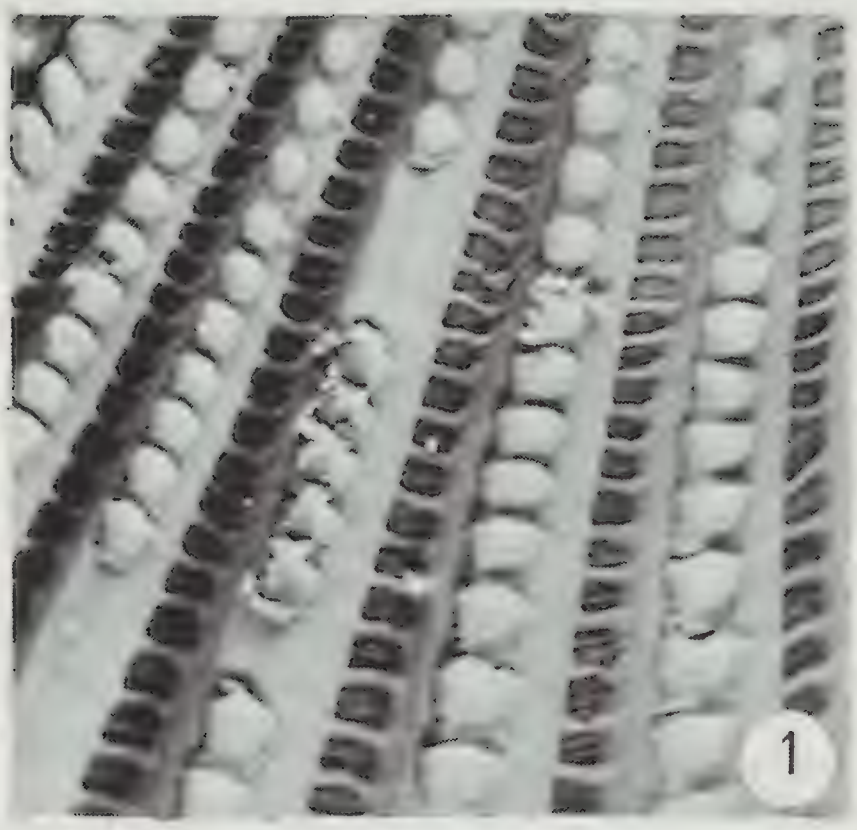
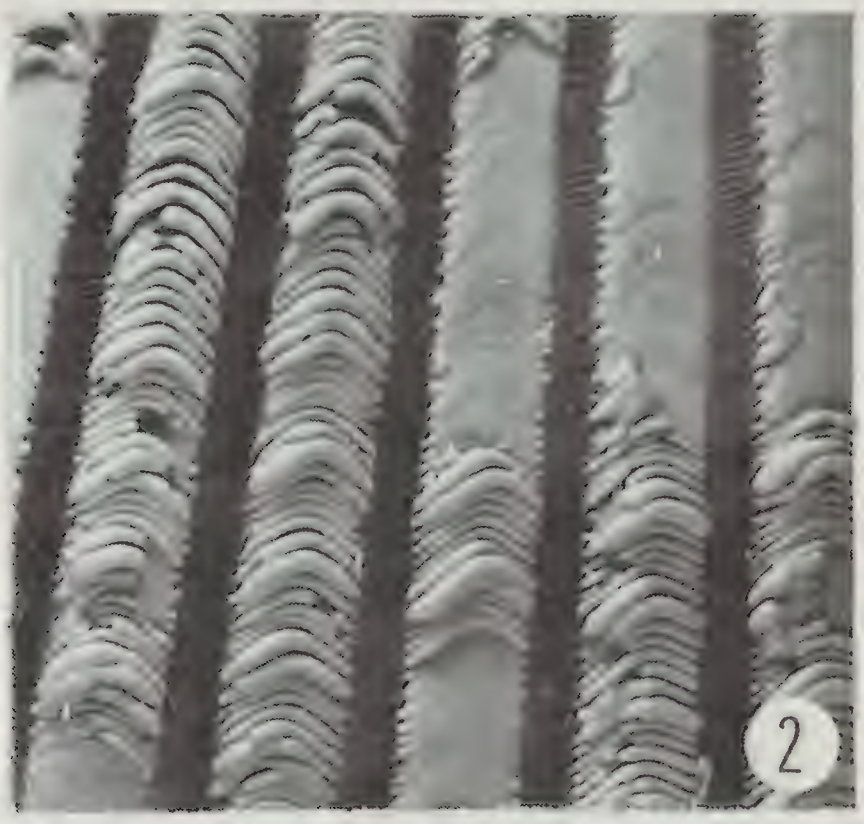
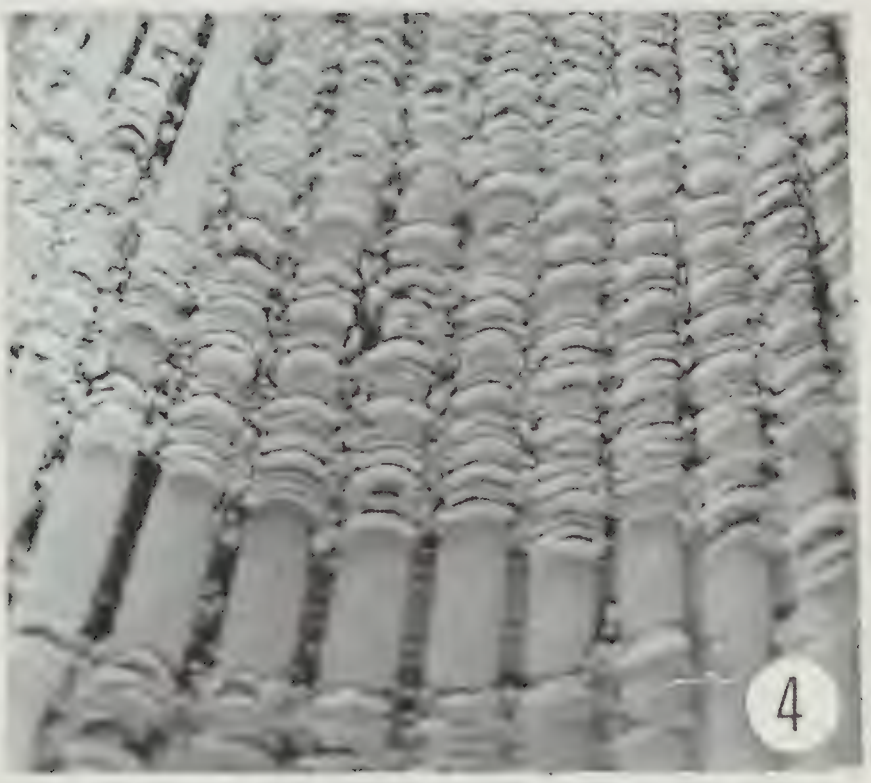
PLATE 6

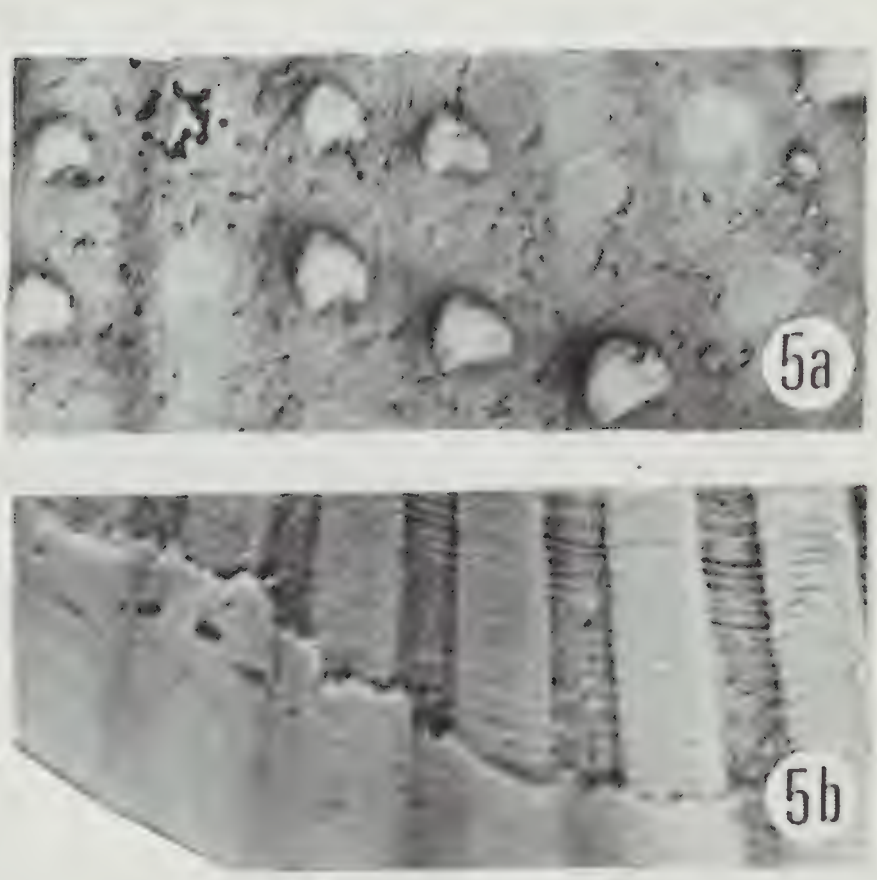
Figures Page

1. *Trigoniocardia (Trigoniocardia) simrothi* (Dall) 180
   Figured specimen, USNM 243536 (X 15).
   Locality: TU 554, Chipola River.
2. *Trigoniocardia (Americardia) media* (Linnaeus) 178
   Figured specimen, USNM 711237 (X 6).
   Locality: TU R-109, north coast of Panamá; Recent.
3. *Trigoniocardia (Trigoniocardia) burnsii* (Dall) 181
   Figured specimen, USNM 243541 (X 22).
   Locality: TU 830, Tenmile Creek.
4. *Trigoniocardia (Americardia) decidua* H. E. Vokes, n. sp. 184
   Holotype, USNM 243543 (X 8).
   Locality: TU 546, Tenmile Creek.
5. *Fragum tunicula* H. E. Vokes, n. sp. 172
   a. Paratype A, USNM 243534 (X 12); showing scattered nodes.
   b. Paratype B, USNM 243535 (X 12); showing non-nodose intritacalx area and surface of shell when intritacalx is removed by erosion.
   Locality of both: TU 453, Alum Bluff, Apalachicola River.
6. *Trigoniocardia (Americardia) columba* (Heilprin) 178
   Figured specimen, USNM 243563 (X 8).
   Locality: TU 201, Bermont Formation, Belle Glade, Florida.









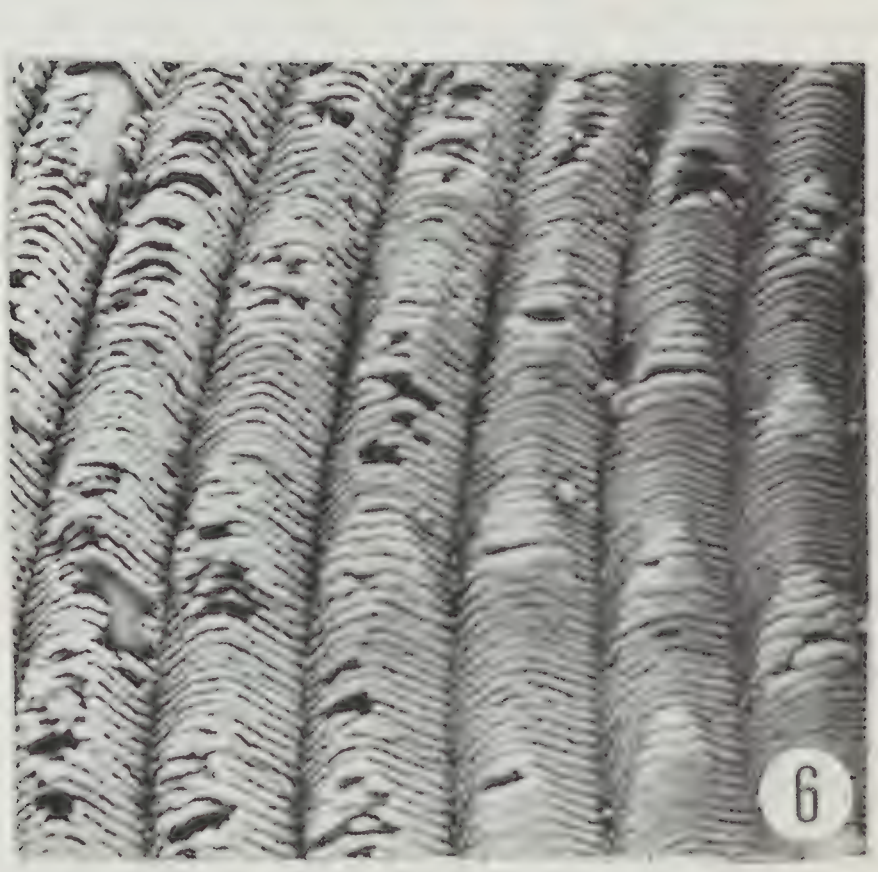


PLATE 6

the median and anterior ribs. In general the number of anterior costae appears to vary between six and ten, but these figures are based upon too few specimens to be significant.

Papyridea bulbosa may be separated most easily from the other Chipola species of the genus by its shape, being proportionately shorter and higher than either of the other two forms and having the greatest valve height posterior to the umbones, almost at the postero-ventral segment. The umbones are located slightly behind the anterior third of the total length. The antero-dorsal margin is rounded, passing into the very regularly and evenly rounded anterior and antero-ventral margin, the arc of the curve gradually flattening off from a position directly below the umbones to the postero-ventral corner which, in turn, is broadly and regularly arched around the posterior end to the relatively straight posterior dorsal edge. The arc of the posterior margin tends to be strongly serrated, with the indentations developed at the site of the median groove of the posterior ribs rather than at the interspaces.

Although no paired valves are available for study, the shape of the valve margin indicates that the anterior ventral gape was moderately strong, and that the posterior one was even greater, proportionately, than it is in the Recent *P. soleniforme.*

P. bulbosa appears to be confined to approximately the lower one-quarter to one-third of the Chipola Formation. At locality TU 458, the stratigraphically highest occurrence of the species, it is associated with *P. multicostula,* n. sp., in the lowest known occurrence of that form.

Figured specimen, USNM 243528; height 23.5 mm, length 27.6 mm, diameter (left valve) 7.5 mm; locality TU 458 (Pl. 4, fig. 4).

Figured specimen, USNM 243556; height 19.1 mm, length 22.0 mm, diameter (right valve) 5.4 mm; locality TU 830 (Pl. 9, fig. 4).

PAPYRIDEA MIOCICA H. E. Vokes, n. sp.
Plate 5, figures 1-4; Plate 9, figure 3

Diagnosis: Shell of moderate size for the genus, elongate-ovate in outline, and of average inflation; umbones situated anterior to the midlength of the valve at approximately two-fifths of the total length; anterior, ventral and posterior margins all arcuate, the ventral more broadly so than the others; posterior dorsal slope almost straight, anterior dorsal margin straight but the shell profile somewhat concave due to the projection of the moderately inflated umbones; anterior gape apparently not developed, posterior one linear, very narrow.

Ornamentation consisting of numerous (32 to 39, see Table 4) radial ribs separated by interspaces that vary in width over different areas of the valve but are always narrower than the primary radials; each interspace, except the most anterior and most posterior ones, bearing a narrow, rounded interriblet that is defined by a distinct, round-bottomed groove. Shape of the primary radials varying on different areas of the valve. A posterior sequence (Pl. 5, fig. 3b), usually of 16 ribs (Table 4), having obliquely flattened costae that have an angulate crest near the posterior side, with numerous narrow, curved, scalelike spinules on the crest and the posterior slope. This sequence covering almost the entire posterior half of the total length of the valve; with the four or five most anterior of the ribs having a flat-topped anterior slope, the immediately posterior costae tending to develop a broad, shallow concavity on this slope, which progressively becomes deep and stronger posteriorly until, on the ribs intersecting the posterior end of the valve, it has developed into a narrow, deep and angulate groove that divides the ribs into two segments with the serrations of the posterior margin marking the site of the grooves and being margined by the two segments of the rib. Costae on the anterior slope usually relatively high and round-topped, marked by curved, scalelike imbrications along their crests (Pl. 5, fig. 3a). The number of these ribs seemingly increases with increasing growth; in the early stages only the anteriormost eight or ten ribs marked by the imbrications, with the ribs of the median portion being round-topped and covered with small granular pustules, those on the crests tending to be somewhat more strongly developed than the ones on the sides and interspace areas. These stronger pustules increasing in size as growth continues and eventually opening ventrally to form erect scalelike imbrications identical with those of the more anterior ribs; in some specimens as many as 16 ribs eventually imbricated in this manner. An elongate, non-ribbed, lunule-like antero-dorsal area present on both valves, but always wider and better developed on the right valve than on the left.

The inner margin crenulate anteriorly and medially, strongly serrated posteriorly; hinge typical of the genus.

Holotype, USNM 243530; height 28.3 mm, length 39.2 mm, diameter (right valve) 9.7 mm; locality TU 825 (Pl. 5, fig. 2).

Paratype A, USNM 243529; height 27.6 mm, length 35.1 mm, diameter (right valve) 9.1 mm (a coral facies variant); locality TU 547 (Pl. 5, fig. 1).

Paratype B, USNM 243531; height 26.5 mm, length 33.3 mm, diameter (left valve) 9.5 mm (a coral facies variant); locality TU 547 (Pl. 5, fig. 3).

Paratype C, USNM 243532; height 19.9 mm, length 27.4 mm, diameter (left valve) 6.8 mm; locality TU 825 (Pl. 5, fig. 4).

Paratype D, USNM 243555; height 30.2 mm, length 37.2 mm, diameter (right valve) 11.0 mm; locality TU 555 (Pl. 9, fig. 3).

Discussion: Two variant forms of a relatively strongly ribbed species of *Papyridea* occur in the middle and upper beds of the Chipola Formation. They agree in details of ornamentation as well as in the degree of variability observable in the number of radials, but are to be distinguished on the basis of differences in outline and overall proportions. The most widely distributed, though less abundant form, is more narrowed posteriorly and has, as a result, the appearance of being considerably more elongate than the other, although comparative measurements indicate that the difference in elongation is not as great as it appears to be; specimens of essentially equal height showing a height to length ratio average of .730:1 in the elongate forms and .791:1 in the others. This latter type is, however, the most abundantly represented form in the collections, with no less than 145 specimens from two localities, TU 547 and TU 555, both of which are in coral-reef facies. While occasional coral specimens have been found at the localities from which the more normal type has been collected, it is here believed that the difference between the two variants is to be interpreted as an ecologic response to differing environmental facies. The more widely distributed, more elongate variant is here described as representing the typical form of the new species.

Papyridea miocica may readily be distinguished from *P. bulbosa* by its different shape, being more elongate with narrower posterior end and with the greatest valve height sub-umbonal, rather than posterior in position. The lack of an anterior gape, and the much reduced posterior one are also distinctive as are all details of the ornamentation. *P. multicostula,* n. sp., differs in having many more radial ribs, with those on the median part of the valve low and weakly developed, giving that portion of the valve an appearance of being almost smooth.

PAPYRIDEA MULTICOSTULA
H. E. Vokes, n. sp.
Plate 4, figures 1-3; Plate 9, figure 5

Diagnosis: Shell of moderate size for the genus, ovate, almost semicircular in outline; umbones relatively low, situated approximately at the anterior two-fifths of the total length; anterior and posterior margins each almost straight with a slight ventral trend, other margins broadly and regularly rounded, the extreme posterior end markedly serrate. Posterior gape relatively strong, the anterior weak, possibly not developed.

Ornamentation of rather strong radial ribs on the anterior and posterior ends with those on the median portion of the valve low, rounded and inconspicuous; all ribs and interspaces except those most anterior and posterior in position granulously pustulate. The anterior ribs (Pl. 4, fig. 3a) flat-topped, obliquely sloping, the apex, toward the anterior side, marked by scalelike imbrications; the imbrications becoming broader and crossing the whole upper surface of the rib during the later stages of growth and also tending to develop on the ventral ends of some of the more anterior ribs of the median segment, with the result that, while there are usually only six to eight imbricated anterior ribs on the younger shells, the number of ribs so ornamented is ten to twelve on adult specimens. The ribs on the median surface broad, very low and round-topped, the intervening interspaces usually about one-half the width of the rib and containing a narrow round-topped inter-rib that is separated from the adjacent primary solely by a linear groove; the combination of ribs and inter-ribs all of approximately the same height such as to give the median area a superficially smooth and unornamented aspect. The posterior ribs (Pl. 4, fig. 3b) tending to be broad and flattened, somewhat sloping antero-ventrally, with small scalelike spines present only on the posterior slope and across the narrow, rugose interspaces. The surfaces of the ribs tri-partite, having relatively narrow raised marginal areas that are strikingly smooth and devoid even of growth lamellae, with the intervening median area rather strongly ornamented by arcuate lamellae representing the former positions of the apex of the deep serrations that mark the posterior end.

The inner margin of the valves are but weakly crenulate medially in keeping with the low surficial ribbing, the crenulations being somewhat stronger anteriorly; hinge typical of the genus.

Holotype, USNM 243525; height 25.4 mm, length 31.8 mm, diameter (left valve) 7.8 mm; locality TU 548 (Pl. 4, fig. 1).

Paratype A, USNM 243526; height 25.4 mm, length 31.6 mm, diameter (right valve) 7.6 mm; locality TU 458 (Pl. 4, fig. 2).

Paratype B, USNM 243527; height 17.5 mm, length 23.7 mm, diameter (left valve) 5.4 mm; locality TU 458 (Pl. 4, fig. 3).

Paratype C, USNM 243557; height 20.8 mm, length 26.2 mm, diameter (right valve) 5.8 mm; locality TU 1048 (Pl. 9, fig. 5).

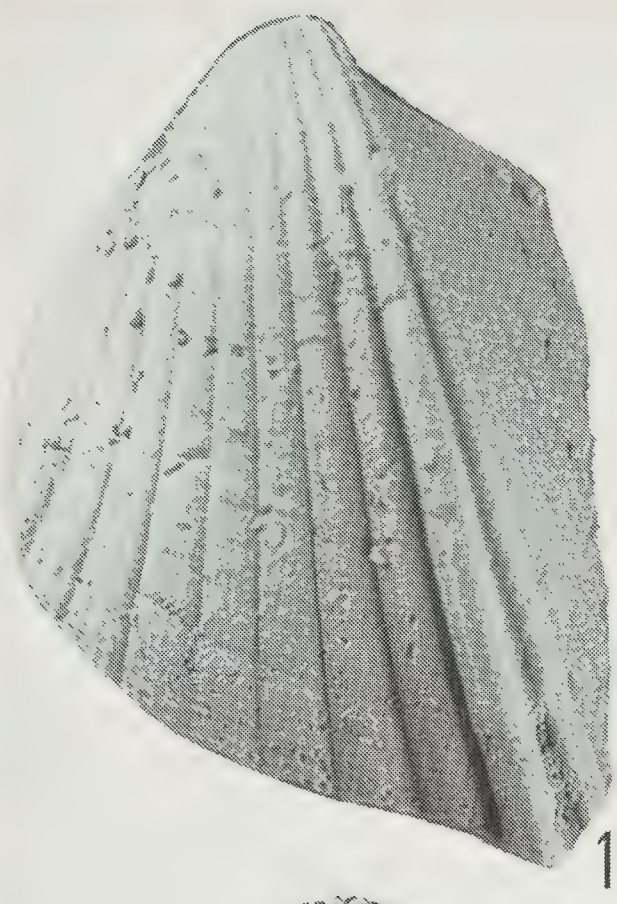
Discussion: Papyridea multicostula may be distinguished at once by the nature of the ribbing on the median surface of the valve. The total number of ribs is highly variable (Table 4) but in general they are more numerous than in the other Chipola species. In contrast, the number of posterior radials is less. Together with *P. bulbosa* it may be distinguished from *P. miocica* in lacking the lunular-like unornamented area on the antero-dorsal margin.

This new species first occurs in the Chipola Formation in association with *P. bulbosa* at TU locality 548, the stratigraphically highest occurrence of the latter form. It is widely present, usually in association with *P. miocica,* n. sp., in the stratigraphically higher collections from localities along the Chipola River and Farley Creek, but it is not represented in those made along Tenmile Creek. The deposits in the two former areas are somewhat sandy and calcareous, often with corals present, both solitary (mainly *Antillophyllia chipolana* Weisbord) and colonial forms representing several different genera; the associated faunas seem to suggest the deposition in open marine waters at depths of about 20 to 40 fathoms. The strata in the upper portion of the section along Tenmile Creek, on the other hand, are generally finer grained, silty with associated clays, and tend to have a fauna of back reef or lagoonal facies, certain of the Bryozoa present even being suggestive of somewhat reduced salinity (Scolaro, 1968, unpubl. diss.).

PLATE 7

Figures Page

1-3. *Fragum tunicula* H. E. Vokes, n. sp. 172
1. Holotype, USNM 243533 (X 4); height 14.7 mm, length 10.5 mm.
Locality: TU 453, Alum Bluff, Apalachicola River.
2. Paratype A, USNM 243534 (X 4); height 10.5 mm, length 8.0 mm.
Locality: TU 453, Alum Bluff, Apalachicola River.
3. Paratype B, USNM 243535 (X 4); height 11.1 mm, length 8.5 mm.
Locality: TU 453, Alum Bluff, Apalachicola River.
Note nature of ribbing when the intritacalx has been removed.
4. *Trigoniocardia (Apiocardia) obovale* (Sowerby) 172
Figured specimen, USNM 711238 (X 4); height 16.1 mm, length 11.0 mm.
Locality: TU R-186, Palo Seco, Pacific Coast, Canal Zone; Recent.
5-8. *Trigoniocardia (Trigoniocardia) simrothi* (Dall) 180
5. Figured specimen, USNM 243536 (X 10); height 7.6 mm, length 6.8 mm.
Locality: TU 554, Chipola River.
6. Figured specimen, USNM 243537 (X 4); height 7.8 mm, length 7.6 mm.
Locality: TU 554, Chipola River.
7. Figured specimen, USNM 243538 (X 4); height 8.2 mm, length 7.4 mm.
Locality: TU 554, Chipola River.
8. Figured specimen, USNM 243539 (X 4); height 9.0 mm, length 8.3 mm.
Locality: TU 554, Chipola River.
Specimen with two narrower costae immediately anterior to the heavy one marking the keel between the median and posterior slopes.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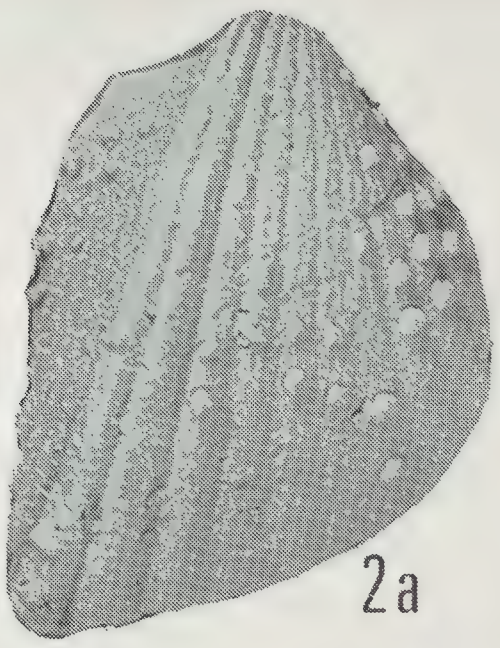
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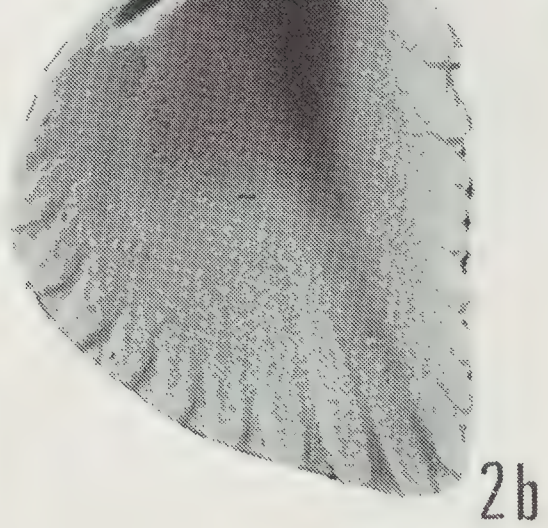
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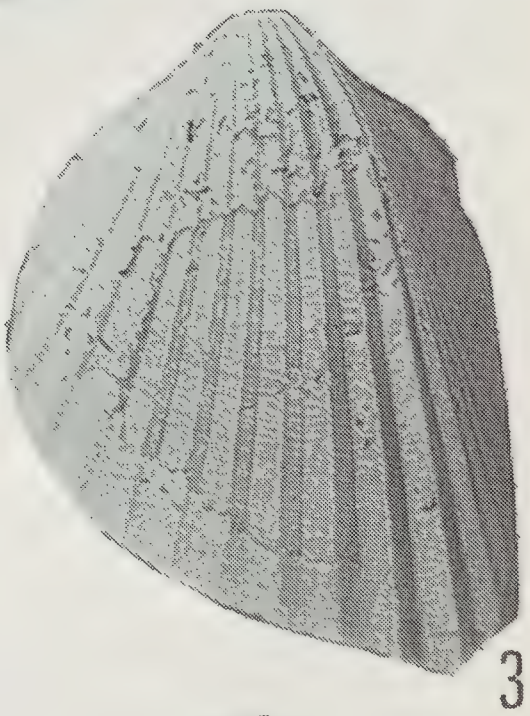
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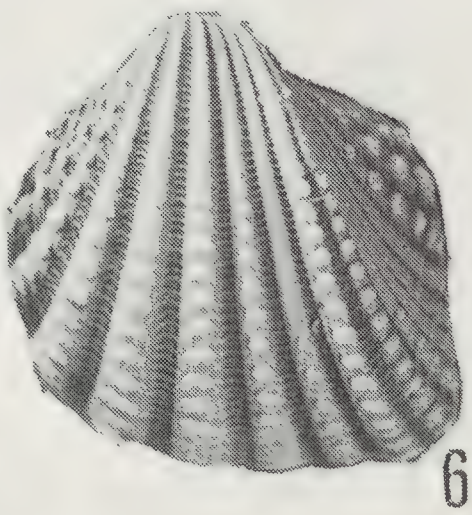
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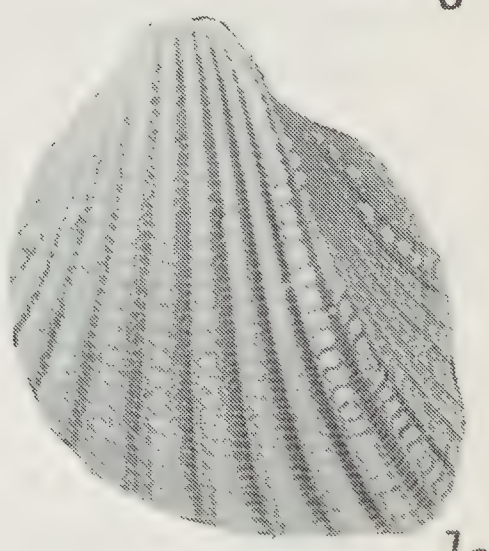
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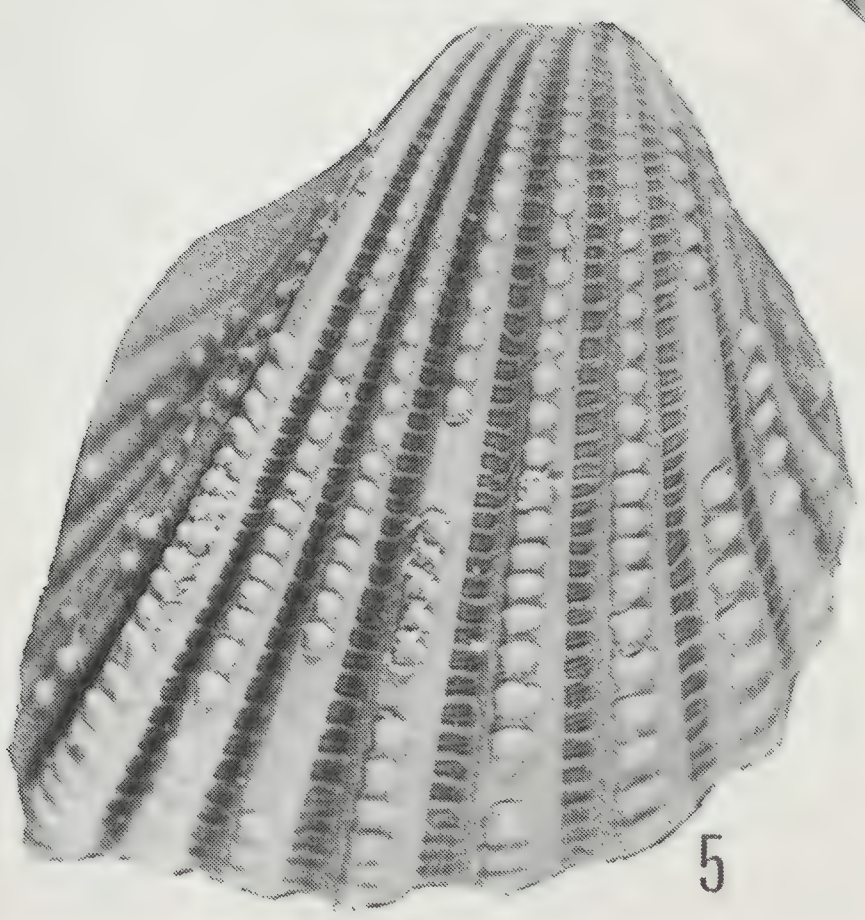
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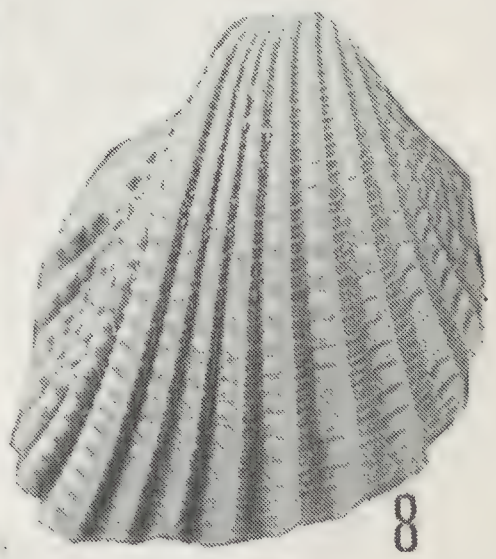
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PLATE 7

Subfamily FRAGINAE Stewart, 1930
Genus FRAGUM Röding, 1798

Fragum RÖDING, 1798, Museum Boltenianum, p. 189.

Type species, by tautonomy, *Cardium fragum* "Gmel." [Linnaeus, 1758]. Recent; tropical Pacific from Amami Islands southward to, and including the East Indies.

The following species seems more closely related to species of the Indo-Pacific genus *Fragum* than to any other group. The exceedingly sharp postero-ventral umbonal ridge, straight and strongly denticulate posterior margin, and especially the details of the hinge structure with well-developed, peg-shaped, subequal cardinals and strong, peg-shaped lateral teeth, the anterior lateral somewhat more distant from the cardinals than is the posterior one, all seem close to the characters exhibited by *Fragum*. In overall shape it probably most closely resembles *Fragum mundum* (Reeve) (1845, pl. 22, sp. 125) originally described from "Lord Hood's Island, Pacific Ocean (found among coral and sand)."

The most similar generic type presently reported from the Western Hemisphere is *Apiocardia* Olsson (1961, p. 252), described as a subgenus of *Trigoniocardia,* with *Cardium obovale* Sowerby as type species by original designation. The hinge of this form (see Pl. 7, fig. 4) differs from that of the present species in having the anterior lateral very closely approximate to the cardinals, with the posterior more distant and peculiarly modified, in that what usually is the raised ventral side of the lateral socket in the right valve has migrated posteriorly and developed into a full-fledged lateral tooth whose anterior end is almost directly behind the socket for the left posterior lateral. This is, in actuality, only an end-product of a tendency also to be observed in the lateral teeth of *Cardium graniferum* Broderip and Sowerby, the type species of *Trigoniocardia* Dall, 1900.

FRAGUM TUNICULA H. E. Vokes, n. sp.
Plate 6, figure 5; Plate 7, figures 1-3

Cardium (Trigoniocardia) alicula DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1103 [in part, *not* pl. 40, fig. 12]; 1903, *ibid.,* v. 3, pt. 6, pl. 48, fig. 5.

NOT *Cardium (Trigoniocardia) alicula* Dall. SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 128 [Holotype, USNM 157549; "Oligocene. Ballast Point, Tampa Bay, Florida"]; DALL, 1915, U. S. Natl. Mus., Bull. 90, p. 144, pl. 25, fig. 8 [same figure as Dall, 1900, pl. 40, fig. 12].

Cardium (Trigoniocardia) berberum DALL, 1915, U. S. Natl. Mus., Bull. 90, p. 145 [in part, references to Dall, 1903, pl. 48, fig. 5, and to occurrences at Alum Bluff and Chipola River only].

NOT *Cardium (Trigoniocardia) berberum* Dall. MANSFIELD, 1937, Florida, Geol. Surv., Bull. 15, p. 249, pl. 18, figs. 2, 3 [Holotype, USNM 166113 from Tampa Limestone, distinguished from "*C. aliculum* Dall from the Chipola formation . . ."].

Cardium [Fragum (Trigoniocardia)] aliculum Dall. GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 140, pl. 23, fig. 15 [same figure as Dall, 1903, pl. 48, fig. 5].

Diagnosis: Shell moderately small, obliquely subtriangular, elevated, with a pronounced keel extending from the posterior side of the umbones to the postero-ventral margin, which is sharply angulated at this point; anterior margin relatively short, broadly rounded into the ventral margin, which is almost straight, but with a tendency to be slightly concave immediately in front of the keel. Ornament of radial ribs with seven to nine ribs, usually eight, on the posterior slope and 11 to 13, usually 12 or 12 on the keel and anterior slope; ribs on posterior slope relatively flat-topped but with rounded sides sloping into narrow, almost linear interspaces; the most dorsal of these ribs tending to be distinctly broader than those ventral to it and the interspace between it and the remaining ribs is approximately twice as wide as those below. Keel usually marked by a strong rib that is noticeably higher and narrower than those anterior to it, although the two immediately anterior are proportionately narrower, higher, and with relatively broader interspaces than the other costae on the anterior surface, these latter tending to be broad and low, with linear interspaces; all anterior interspaces marked by a ladder-like ornamentation of low, transverse growth lamellae that are most visible in the three or four broader interspaces immediately in advance of the keel. Surfaces of all ribs with transversely elongated and rounded pustules; these, however, being part of the intritacalx are easily eroded away, together with the thin, smooth and shiny outer shell layer. When this is lost, the ornamentation has a wholly different appearance, with a chalklike shell marked by flat-topped costae that are straight sided and separated by flat-bottomed interspaces, both costae and interspaces being crossed by the low, transverse growth lamellae; inner margins of anterior and ventral areas fluted internally, posterior margin rather strongly denticulate.

Holotype, USNM 243533; height 14.7 mm, length 10.5 mm, diameter (left valve) 5.8 mm; locality TU 453, lower bed, Alum Bluff (Pl. 7, fig. 1).

Paratype A, USNM 243534; height 10.5 mm, length 8.0 mm, diameter (right valve) 3.9 mm; locality TU 453 (Pl. 6, fig. 5a; Pl. 7, fig. 2).

Paratype B, USNM 243535; height 11.1 mm, length 8.5 mm, diameter (left valve) 3.6 mm (a decorticated specimen); locality TU 453 (Pl. 6, fig. 5b; Pl. 7, fig. 3).

(Note: These measurements made with the straight posterior margin in a vertical position.)

Discussion: Fragum tunicula differs at sight from other Chipola cardiid species in its much more strongly keeled shell with shorter posterior end, narrower interspaces between the ribbing when the intritacalx is present, and more sharply rounded posterior end. It appears to differ from the true Tampa Limestone *C. alicula* of Dall in its somewhat more flaring posterior margin, especially toward the dorsal end; conversely, the anterior side of the Tampa species is proportionately broader and more flaring so that the overall height: length relationship appears to be essentially the same.

Few specific names of Florida Miocene species have as complex a history as the "*Cardium alicula*" of Dall and the present species. Although not explicitly so stated by Dall, it appears that the name *C. alicula* was applied initially to a specimen from the Tampa Limestone at Ballast Point in Tampa Bay – the original of Dall's 1900, plate 40, figure 12 – with the subsequent acquisition of specimens from Alum Bluff leading to a revision of the original description and the preparation of the illustration that was printed in 1903 on plate 48, figure 5 of the "Contributions to the Tertiary Fauna of Florida," Part 6. In 1905, in Schuchert, *et al.,* Dall designated the originally illustrated Ballast Point specimen as the holotype of the species with USNM number 157549. Later, in 1915 (p. 144), he again cited *C. alicula* from the Tampa Limestone with synonymic reference to the original 1900 illustration "pl. 40, fig. 12 (only)," but with the distribution said to be "Oligocene of the Tampa silex beds, Ballast Point, Tampa Bay, and of the lower bed at Alum Bluff, Chattahoochee River [now the Apalachicola River], Florida. Dall and Burns. U. S. Natl. Mus. No. 165209." At the same time, on the next page (p. 145), he proposed the name "*Cardium (Trigoniocardia) berberum,* new species," without illustration, but with synonymic reference to "*Cardium (Trigoniocardia) alicula* (part), . . . pl. 48, fig. 5, . . . (not pl. 40, fig. 12)". The original statement concerning *berberum* was:

> "Oligocene of Tampa silex beds and of the lower bed at Alum Bluff, Florida, and of the Chipola River marl, Calhoun County, Florida. U. S. Nat. Mus. No. 166113.
>
> "When first described it was thought that the Ballast Point specimen of *C. alicula* was worn and that its differences from the Chipola form were due to erosion. The recovery of a well-preserved valve from the silex beds, together with specimens of the Chipola form, has enabled a more exact comparison to be made, which shows that the form from the Chipola marl beds is distinct. It may be recognized by its more narrow form and by the very conspicuous denticulation of the margin of the truncated end of the valves. *C. alicula,* so far as known, is confined to the Ballast Point horizon, but the present species is present also at Chipola. The Ballast Point specimens are U. S. Nat. Mus. No. 166113."

It seems clear that Dall was proposing the name *C. berberum* as a substitute name for the "*alicula*" of his earlier plate 48, figure 5, but he used the designation of "new species" rather than "new name." In 1937, Mansfield (p. 249, pl. 18, figs. 2, 3) restricted the name *C. berberum* to the valve from the Tampa silex beds, giving a formal description and stating that the "Holotype, left valve (U. S. Nat. Mus. No. 166113) measures: Length, 8.7 mm; height, 13.3 mm; semidiameter, 4.5 mm." [This specimen is better termed the "lectotype," since it was not formally designated as holotype by Dall whose hypodigm also included the "specimens of the Chipola form."] Mansfield then added the statement that "*Cardium berberum* is closely related to *C. aliculum* Dall from the Chipola formation of Florida but differs from it in having a narrower and more sloping area at and behind the umbo and 3 to 4 more ribs in

front of the posterior ridge. The outlines of the two species are similar."

In the meantime, Gardner, in 1926, overlooking or ignoring both Dall's citation of the type of *C. alicula* as being the Tampa form and his 1915 statement that the species "so far as known is confined to the Ballast Point horizon," reported *"aliculum"* as from the Chipola fauna, adding: "Cotypes: U. S. Nat. Mus. No. 157550" [Dall had said in 1905 that the holotype bore the number 157549] and "Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Florida." This action was clearly invalid, but seems to have been accepted by Mansfield in 1937 (p. 249) in comparing *C. berberum* with "*C. aliculum* Dall from the Chipola formation" and, on the following page (1937, p. 250), listing "*Cardium (Trigoniocardia)* cf. *C. aliculum* Dall" with synonymic citations to Dall, 1900, "p. 1103 (part), pl. 40, fig. 12" and 1915, "p. 144, pl. 25, fig. 8." Mansfield then observes that: "Two valves from the 'silex beds' of the Tampa limestone, Ballast Point, Tampa Bay, Fla., were identified as *Cardium aliculum* Dall, one a right valve (U. S. Nat. Mus. No. 157549) figured by Dall in 1900, and the other a left valve (U. S. Nat. Mus. No. 165209) . . . The 'silex beds' specimens when compared with specimens of *C. aliculum* Dall, *a species described from the Chipola formation* [italics mine], reveal, so far as can be discerned, similar external sculpture but appear to differ from the Chipola species in having a narrower shell with less produced posterior-ventral area." Thus Mansfield followed Gardner's lead and

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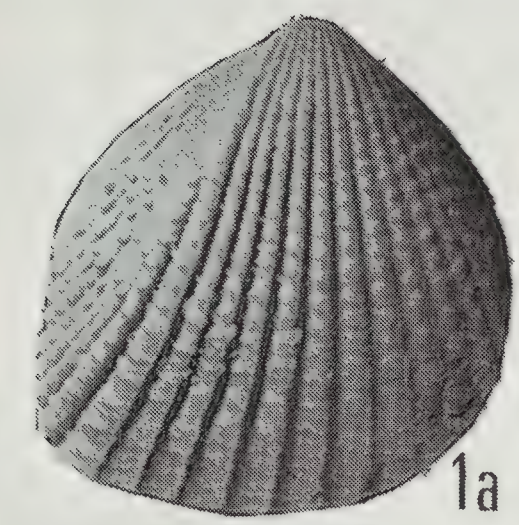
PLATE 8

Figures Page

1-3. *Trigoniocardia (Trigoniocardia?) burnsii* (Dall) 181
1. Figured specimen, USNM 243540 (X 4); height 8.2 mm, length 7.5 mm. Locality: TU 546, Tenmile Creek.
2. Figured specimen, USNM 243541 (X 4); height 7.4 mm, length 7.0 mm. Locality: TU 830, Tenmile Creek.
3. Figured specimen, USNM 243542 (X 4); height 6.8 mm, length 6.5 mm. Locality: TU 830, Tenmile Creek.
4-6. *Trigoniocardia (Americardia) decidua* H. E. Vokes, n. sp. 184
4. Holotype, USNM 243543 (X 4); height 12.3 mm, length 11.6 mm. Specimen with intritacalx. Locality: TU 546, Tenmile Creek.
5. Paratype A, USNM 243544 (X 4); height 11.6 mm, length 11.8 mm. Locality: TU 830, Tenmile Creek.
6. Paratype B, USNM 243545 (X 4); height 15.6 mm, length 15.0 mm. Specimen with intritacalx eroded away. Locality: TU 830, Tenmile Creek.
7. *Laevicardium compressum* (Dall) 185
Figured specimen, USNM 243546 (X 1.5); height 21.8 mm, length 20.8 mm. Locality: TU 458, Chipola River.
8-10. *Dinocardium chipolanum* (Dall) 185
8. Figured specimen, USNM 243547 (X 1); height 30.5 mm, length 30.3 mm, diameter (paired valves) 23.2 mm. Locality: TU 458, Chipola River.
9. Figured specimen, USNM 243548 (X 1); height 33.6 mm, length 33.5 mm. Locality: TU 458, Chipola River.
10. Figured specimen, USNM 243549 (X 1); height 45.7 mm, length 44.3 mm. Locality: TU 827, Farley Creek.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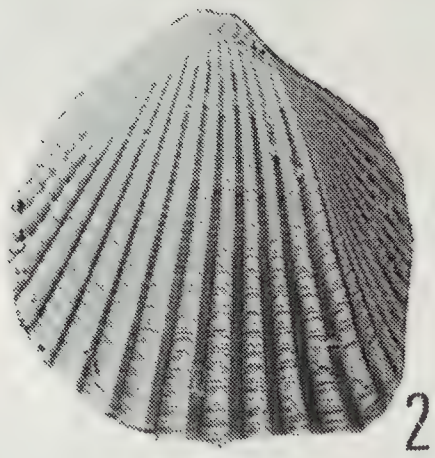
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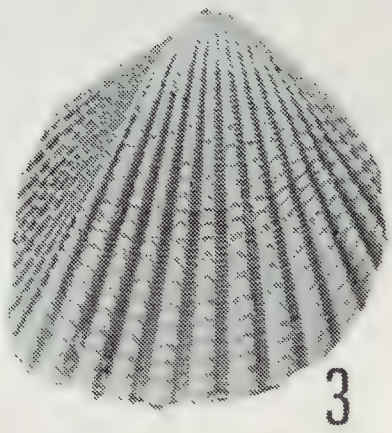
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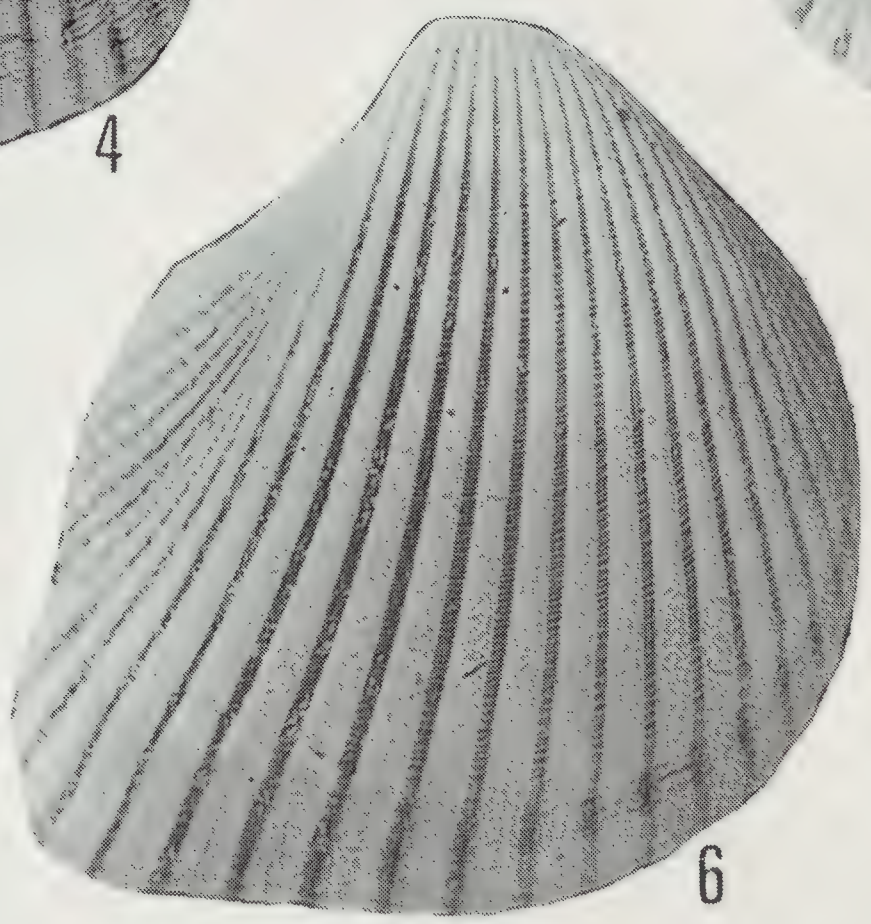
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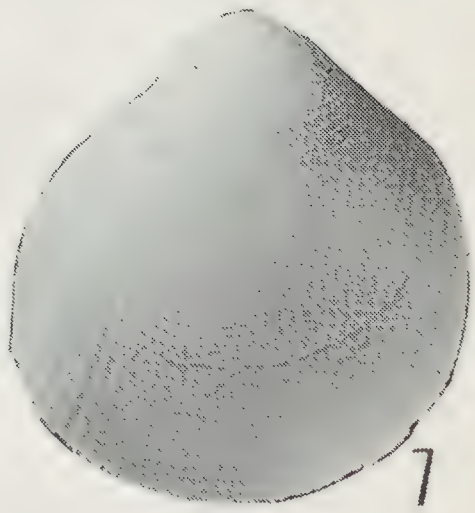
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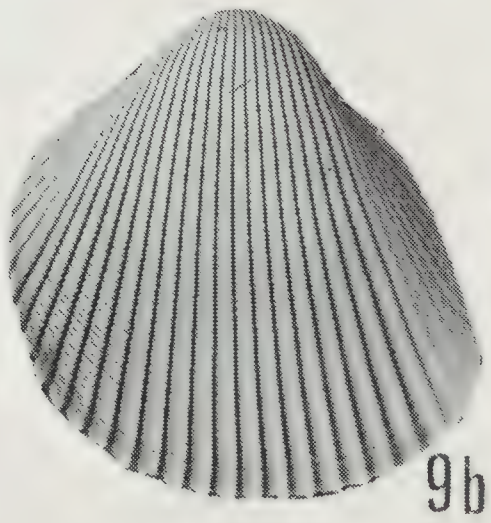
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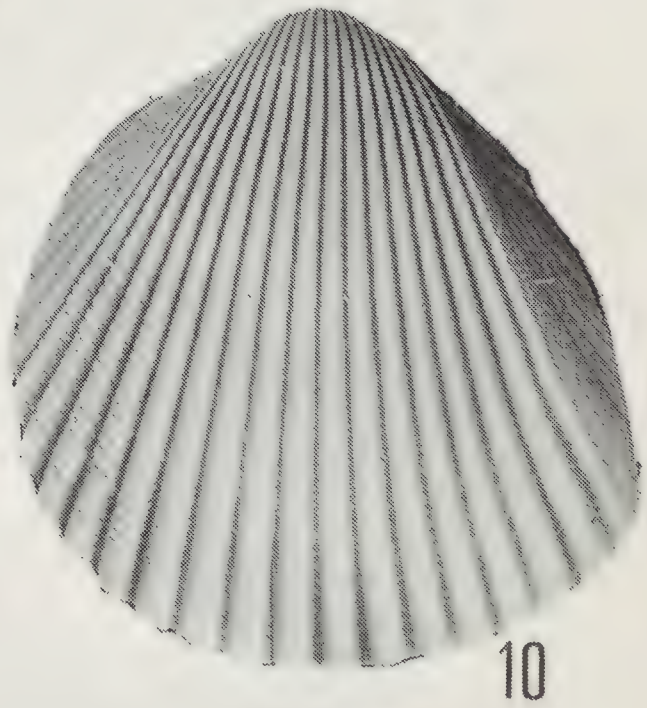
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PLATE 8

completely ignored the conclusions of Dall, which had priority and were binding, even though he, like Dall, was discussing the fauna of the Tampa Limestone.

Finally, it is to be noted that Gardner (1926, p. 140) also distinguished the Chipola species from the Tampa form, stating that "the Ballast Point specimens are relatively higher and much narrower dorsally, with no trace of a constriction either behind or in front of the posterior keel and with fewer and even lower costals."

To summarize the above history, it appears that three species, two from the Tampa Limestone of Ballast Point, Tampa Bay, Florida, and the third from the Chipola fauna of northern Florida, have been confused under the names *alicula,* or *aliculum,* and *berberum* by Dall (1900, 1905, 1915), Gardner (1926), and Mansfield (1937), with both of the latter authors agreeing that the two Tampa species differed from that found in the Chipola fauna, both in shape and in number of costals. A count of the ribbing on 25 valves from the Chipola as exposed in the lower beds at Alum Bluff as compared with the two specimens of *alicula* from Tampa, mentioned by Dall, plus those of the "holotype" of *berberum* gives the comparison shown in Table 5.

The numbers indicated do not agree with Gardner's statement that the Tampa specimens had "fewer . . . costals"; however, it must be added that they are notably lower and less distinct than are those of the Chipola form and, indeed are so much so as to make it most difficult to be certain as to the actual number present, especially on the more anterior dorsal areas of the two valves. These counts serve to document the fact that the Chipola form does differ from the Tampa ones, especially when the differences in shape noted by Mansfield and Gardner are also taken into account.

As a result, there is no escaping the conclusion that the Chipola species that was referred to by Gardner as *"Cardium [Fragum (Trigoniocardia)] aliculum* Dall" remains without a valid scientific name. It is here denominated as *Fragum tunicula,* new species. Dall's specific name *alicula* was derived from a Latin noun of feminine gender that was the name for a light upper garment, and was probably applied in allusion to the thin, deciduous, pustule-bearing outer shell layer or intritacalx that is easily worn off to leave smooth-topped radial ribs. (Being used as a noun in apposition, see Code of International Nomenclature, Article 11 (g) (2), the specific name should not be changed to agree in gender with the generic epithet as it would be if adjectival in origin, and hence should continue to be cited as *alicula,* rather than *aliculum.*) The suggested substitute name *berberum* was apparently derived from the Greek "berberion," the name applied to a shabby outer garment. The name *tunicula* here proposed for the species from the Chipola Formation is selected in agreement with the implication of these previous terms, being the diminutive form of the Latin feminine noun *"tunica"* – a garment or skin.

Finally, it is to be noted that while Dall, in the original description of *C. alicula* cited it as from the Ballast Point silex beds, the lower bed at Alum Bluff, and "the marls of the Chipola River, Calhoun County, Florida," and Gardner listed it as common at "locality No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla." and abundant in three collections from the lower bed at Alum Bluff, the Tulane University collections contain only two speci-

TABLE 5

	anterior area						posterior area		
Number of ribs	11	12	13	14	15	16	7	8	9
Chipola species	12	10	3	–	–	–	4	16	5
C. alicula	–	–	1	1	–	–	2	–	–
C. berberum (type)	–	–	–	–	–	1	–	–	1

mens from the Chipola River area that represent the species figured by Dall in his 1903, plate 48, figure 5 illustration. There are, however, 153 valves in the material from the lower bed at Alum Bluff.

Collections from within the area of one mile below the site of the former Bailey's Ferry contain more than 11,000 valves of cardiid species (see Table 2), but not one is representative of the present form. Both Chipola River specimens present in our collections come from strata higher in the section (localities TU 458 and TU 459), which contain other species suggesting their correlation with the Alum Bluff strata. It seems quite clear that the collections examined by Dall and Gardner were inadvertently mixed, either by Burns the collector, or by Museum technicians at the time when the material was being unpacked and processed for study. This is further confirmed by the fact that the specimens bearing the U. S. Nat. Mus. no. 157550 which were referred to by Miss Gardner as the "Cotypes" and were said to have come from "locality: No. 2213, 1 mile below Baileys Ferry . . ." contain matrix remnants that are composed of a poorly sorted mixture of angular quartz sand in a yellow clay, whereas the strata of the area one mile below Bailey's Ferry is mainly a lime and clay mixture that is almost wholly lacking in quartz. The quartz sand/clay matrix is that which is characteristically present at Alum Bluff, and there can be no doubt whatsoever, but that these specimens at least, are from that locality and horizon.

Genus TRIGONIOCARDIA Dall, 1900

Trigoniocardia DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1075.

Type species, by original designation, *Cardium graniferum* Broderip and Sowerby, 1829. Recent; Gulf of California to northern Peru.

As noted by Stewart (1930, p. 267) the species of the typical subgenus of *Trigoniocardia* have the anterior lateral teeth "crowded against" the cardinals, while in the subgenus *Americardia* they "are not so close to the cardinals and may be almost as far removed as the posterior laterals" resulting in "a more symmetrical hinge" (p. 268). Despite the statement to the contrary by Olsson (1961, p. 251) *Trigoniocardia* s.s. as well as *Americardia* is marked by the presence of a thin, ornamented, deciduous, outer layer, or intriticalx (see D'Attilio and Radwin, 1971). That of *Trigoniocardia* is distinguished by the presence of discrete nodes, usually more or less transverse in position, that mark the central parts of the ribs. The spaces between the nodes appear to be completely smooth on unworn specimens but may show weak lineations of growth increments with wear. The interspace areas have a distinctly ladder-like ornament of raised transverse ridges that may be seen, on slightly worn specimens, to be superimposed upon and somewhat angularly discordant from the growth lamellae, especially toward the anterior ventral margin (see Pl. 6, fig. 1).

This has been observed on specimens of the type species from Tulane University locality R-176, off Jesusita Island, Gulf of Nicoya, Costa Rica; on *T. simrothi* Dall, from the Chipola Formation; on specimens of the Bowden form identified by Woodring (1926, p. 142, pl. 19, figs. 8, 9) as the Santo Domingo Miocene species *"Cardium" haitense* Sowerby, (1850, p. 52, pl. 10, fig. 11); on the Costa Rican "Pliocene" [= early Pleistocene] *"Cardium (Fragum)" callopleurum* Gabb (1881, p. 375, pl. 47, fig. 77), from the Moín Formation, and its apparent ancestor *"Cardium" heredium* Olsson (1922, p. 227, pl. 27, fig. 10), from the lower Pliocene Rio Banano Formation (= "Gatun" of Olsson); on the Caloosahatchee species *T. wilcoxi* Dall (1900, p. 1106; 1903, pl. 48, fig. 9); and on the Recent *T. antillarum* (d'Orbigny) (1845, p. 338, pl. 27, figs. 53-55). One or two exceptionally well-preserved specimens of *T. simrothi* Dall permit the suggestion that both the transverse ridges and the inter-ridge areas were overlain by an exceedingly thin and tenuous glaze, apparently easily worn away and wholly absent from most specimens examined.

The intritacalx of *Americardia* has a very different expression, but also seems to show more variation between different species than does that of *Trigoniocardia.* The basic form consists of close concentric threads

that are arched on the tops of the radial ribs, where, on *T. (A). media* (Linnaeus), – the type species (see Pl. 6, fig. 2), – approximately every sixth and seventh or seventh and eighth threads are somewhat broader and higher than the five or six intervening ones and simulate transverse nodes. The interspaces are much more finely cross-striated, with usually three elevated threads for each of those on the rib tops; these tend to unite on the sides of the ribs to form the coarser ones on the upper surface. The new Chipola species described below has a similar intritacalx (Pl. 6, fig. 4) except that there is more variation in the detail of the rib-top ornament. In this form the occurrence of the more coarse and elevated threads is irregular, with, at times, as many as five fine threads intervening between adjacent coarser ones, but more often there are only one or two, and occasionally none. Furthermore, rather than appearing as paired units as in *T. media,* the coarser threads tend to be single, being paired only in those more rare cases in which no intervening fine ones are present. The intriticalx of the Caloosahatchee and Bermont species *T. (A.) columba* (Heilprin) (1887, p. 93, pl. 9, fig. 26, 26a; + *C. arestum* Dall, 1900, p. 1102, pl. 40, fig. 10) shows yet another variation in that the threads on the rib tops tend, periodically, to become differentially elevated, superficially simulating nodes (see Pl. 6, fig. 6). Typically there are about ten to twelve fine threads between each two nodelike structures, which, in turn, are composed of from four to six threads. Careful "dissection" reveals no true nodose swelling underlying the

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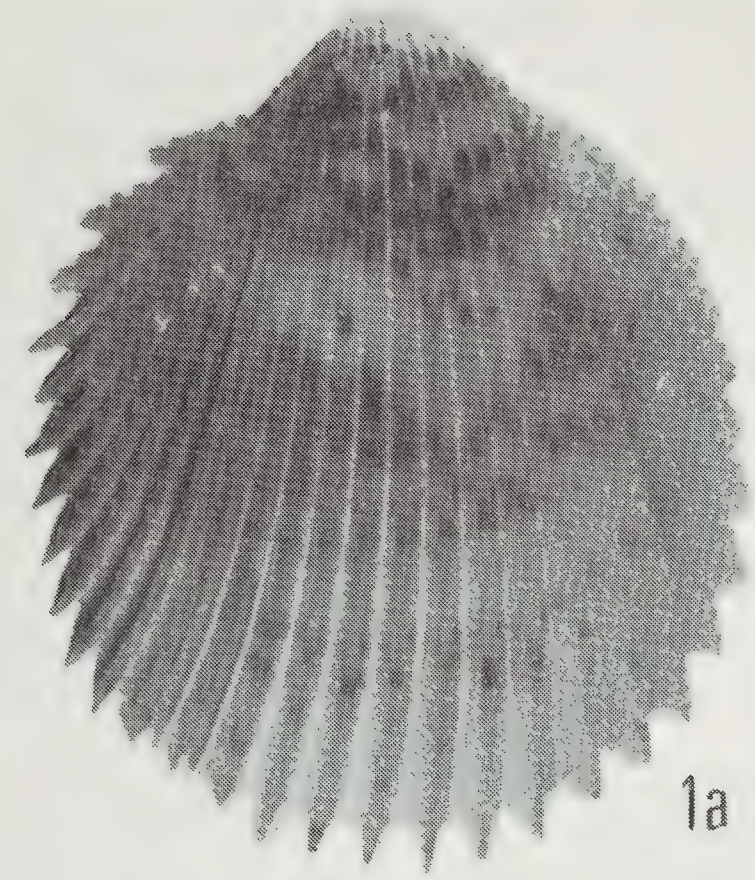
PLATE 9

Color patterns under ultraviolet light (X 1.5)

Figures Page

1. *Trachycardium (Conilocardium) cestum* (Dall) 158
   a. Figured specimen, USNM 243550; height 38.7 mm, length 33.2 mm.
      Locality: TU 458, Chipola River.
   b. Figured specimen, USNM 243551; height 48.5 mm, length 38.2 mm.
      Locality: TU 555, Chipola River.
2. *Laevicardium compressum* (Dall) 185
   a. Figured specimen, USNM 243552; height 20.4 mm, length 19.7 mm.
      Locality: TU 950, Chipola River.
   b. Figured specimen, USNM 243553; height 22.0 mm, length 20.7 mm.
      Locality: TU 950, Chipola River.
3. *Papyridea miocica* H. E. Vokes, n. sp. 168
   Paratype D, USNM 243555; height 30.2 mm, length 37.2 mm.
   Locality: TU 555, Chipola River.
4. *Papyridea bulbosa* (Dall) 165
   Figured specimen, USNM 243556; height 19.1 mm, length 22.0 mm.
   Locality: TU 830, Tenmile Creek.
5. *Papyridea multicostula* H. E. Vokes, n. sp. 169
   Paratype C, USNM 243557; height 20.8 mm, length 26.2 mm.
   Locality: TU 1048, Farley Creek.
6. *Acanthocardia propeciliare* (Dall) 152
   Figured specimen, USNM 243558; height 25.1 mm, length 22.6 mm.
   Locality: TU 555, Chipola River.
7. *"Trachycardium" parile* (Dall) 156
   Figured specimen, USNM 253559; height 25.7 mm, length 23.4 mm.
   Locality: TU 555, Chipola River.
8. *Dinocardium chipolanum* (Dall) 185
   Figured specimen, USNM 243554; height 39.8 mm, length 38.3 mm.
   Locality: TU 825, Farley Creek.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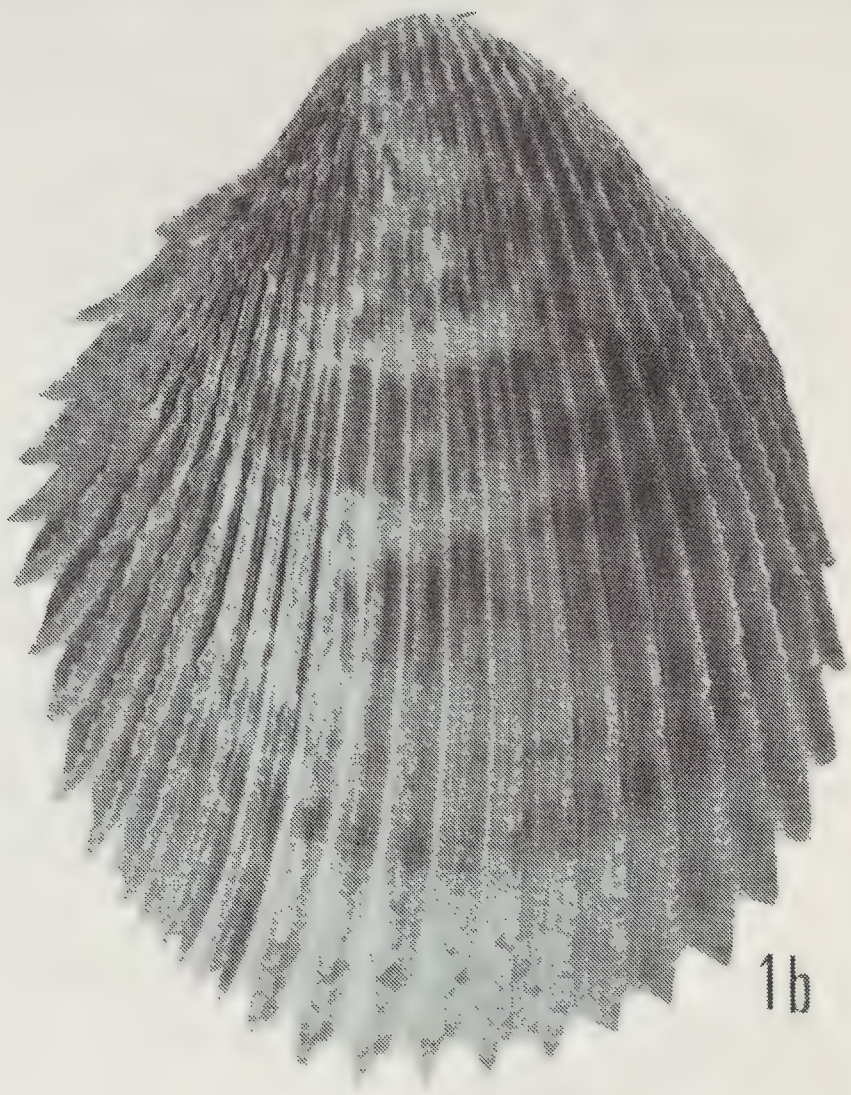
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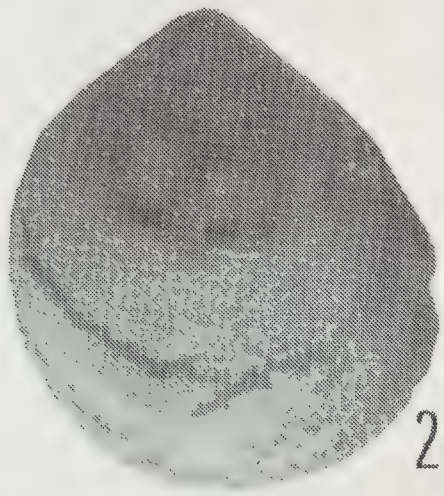
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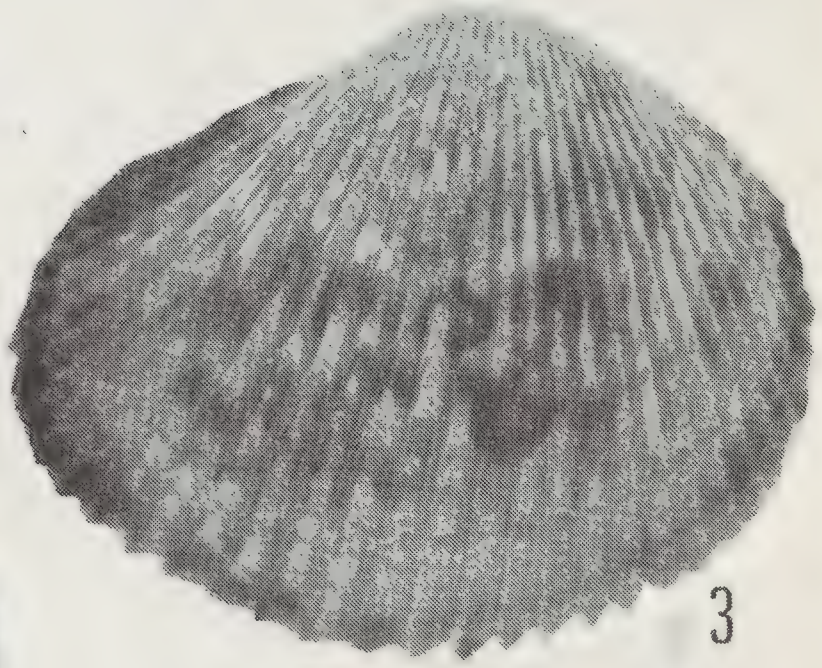
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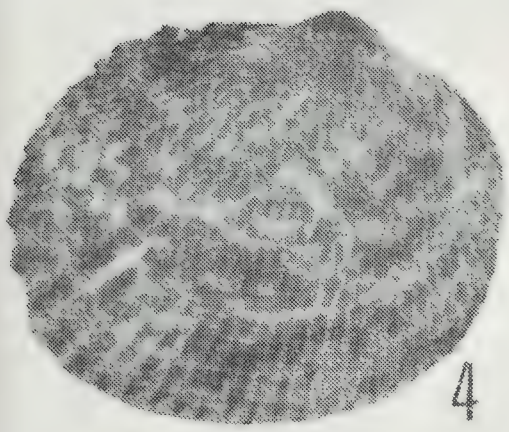
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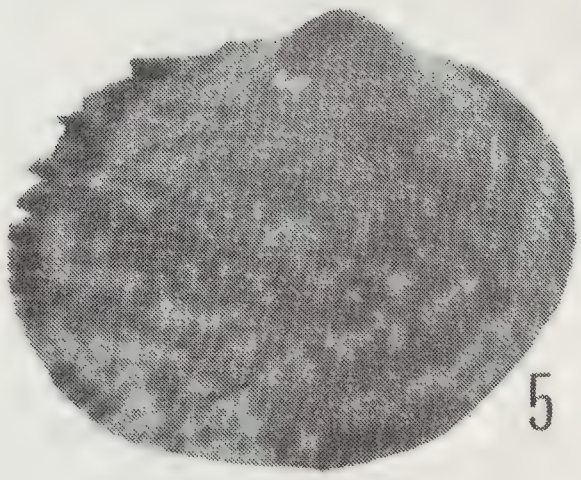
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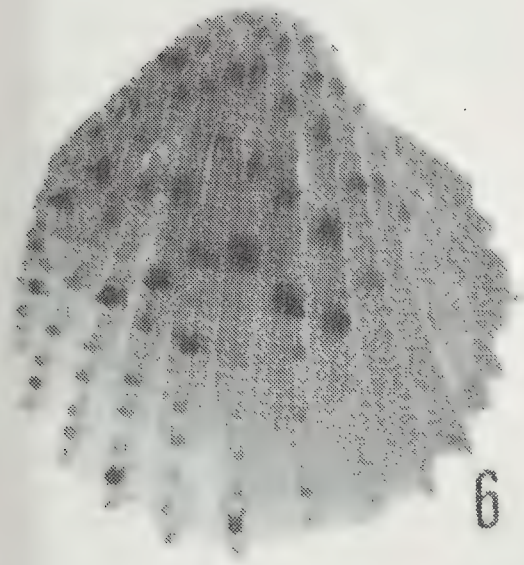
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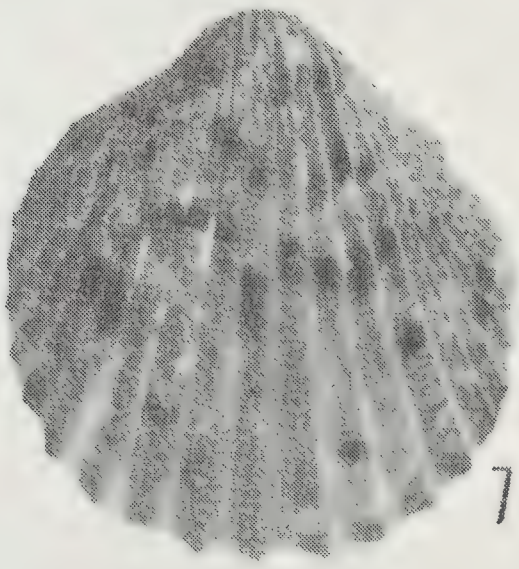
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PLATE 9

threads either in the lower levels of the intritacalx or on the ribs themselves, which are completely smooth when the layer is removed.

The intritacalx of *"Cardium (Fragum)" burnsii* Dall is, in some respects, more or less intermediate in character between that present on typical *Trigoniocardia* and that of the subgenus *Americardia.* It has the discrete nodes of *Trigoniocardia,* but the inter-nodal area has transverse threading similar to that in the intervals between the coarse elevated threads of *Americardia.* Similarly, the hinge shows much variation with respect to the position of the anterior lateral teeth. In the majority of the specimens examined they tend to be closely approximate to the cardinals in typical *Trigoniocardia* position, but in some, usually smaller and more immature individuals, they are almost as distant as in typical forms of *Americardia.* Accordingly, this species is here only questionably referred to the typical subgenus.

TRIGONIOCARDIA (TRIGONIOCARDIA) SIMROTHI (Dall)

Plate 6, figure 1; Plate 7, figures 5-8

Cardium (Trigoniocardia) Simrothi DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1104; 1903, *ibid.,* v. 3, pt. 6, pl. 48, fig. 8; SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 132 [Holotype, USNM 114767; "Oligocene, Chipola River, Calhoun County, Florida"].

Cardium [Fragum (Trigoniocardia)] simrothi Dall. GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 141, pl. 23, fig. 10 ["Cotypes: U. S. Nat. Mus. No. 114767. Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla."].

Trigoniocardia simrothi (Dall). WEISBORD, 1964, Bulls. Amer. Paleontology, v. 45, no. 204, p. 261 [compared with *T. caboblanquensis* Weisbord].

Trigoniocardia (s.s.) *simrothi* (Dall). GLIBERT and VAN DE POEL, 1970, Inst. Roy. Sci. Nat. Belg., Mém., ser. 2, fasc. 84, p. 59 ["Miocene (Chipola). Oak Grove (Floride, U.S.A.)"].

As may be noted in Table 2, this species is the dominant cardiid form in terms of numbers of valves present in our Chipola collections, a position that it achieves because of its abundance in the faunas from the deposits exposed in the banks of the Chipola River, where Gardner (1926, p. 102) noted it as being prolific – the only cardiid species so designated in her study. Here it occurs in greatest profusion in approximately the lower third to lower half of the geologic section, and is definitely less common in the upper part of the section exposed along the river and on Farley Creek. For some reason not presently clear, it is exceedingly rare (only two specimens present) in the collections from Tenmile Creek, where the lower strata are well-exposed.

While only slightly suggested by Dall's original figure, the most distinctive feature of this species is the tendency, mentioned by Gardner (1926, p. 141), for "the two ribs directly in front of the posterior keel [to be] commonly a little narrower than those anterior to them and [to] seem to lose their ornamentation more readily, thus lending to the costal [rib] which defines the posterior keel a prominence which it would not otherwise possess." While two is the usual number of such smaller ribs, some specimens show only one and others have as many as three. These ribs are not only smaller in width, but also in elevation and thus tend to give the ventral margin a distinct but shallow insinuation directly anterior to the sharply projecting keel-rib.

The number of ribs varies to only a minor extent, with eight or nine on the posterior slope and 11 to 14, including the keel-rib, on the anterior segment. The number in the latter area is more commonly 13 than the 11 noted by Dall; the variation appears, however, to be mainly a function of the width of the most dorsal rib in the series. In some specimens it is wide, low and smooth; these tend to have 11 or 12 ribs. In others, it is narrow, often nodose; these tend to have 13 or 14 ribs. The two types occur together and apparently represent only normal variation, although there does seem to be proportionately more of the first type in the basal strata than in those higher in the section.

The citation of this species from Oak Grove by Glibert and Van de Poel (1970, p. 59) is almost certainly an error. Neither Dall nor Gardner mention its occurrence in that fauna and it is not represented in the Tulane collections, where the dominant cardiid is *Trigoniocardia apateticum* (Dall) (1900, p.

1105; 1903, pl. 48, fig. 6), which is superficially similar to *T. simrothi* but lacks the smaller ribs in front of the keel.

Figured specimen, USNM 243536; height 7.6 mm, length 6.8 mm, diameter (right valve) 3.0 mm; locality TU 554 (Pl. 6, fig. 1; Pl. 7, fig. 5).

Figured specimen, USNM 243537; height 7.8 mm, length 7.6 mm, diameter (left valve) 3.3 mm; locality TU 554 (Pl. 7, fig. 6).

Figured specimen, USNM 243538; height 8.2 mm, length 7.4 mm, diameter (left valve) 3.4 mm; locality TU 554. A specimen with the ribs in front of the keel-rib not markedly narrower than the rest (Pl. 7, fig. 7).

Figured specimen, USNM 243539; height 9.0 mm, length 8.3 mm, diameter (right valve) 3.8 mm; locality TU 554 (Pl. 7, fig. 8).

TRIGONIOCARDIA (TRIGONIOCARDIA?) BURNSII (Dall)

Plate 6, figure 3; Plate 8, figures 1-3

Cardium (Fragum) Burnsii DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1101 [in part]; 1903, *ibid.,* v. 3, pt. 6, pl. 48, fig. 15; SCHUCHERT *et al.,* 1905, U. S. Natl. Mus., Bull. 53, p. 128 [Holotype, USNM 114770; "Oligocene, Chipola River, Calhoun County, Florida"]; WOODRING, 1925, Carnegie Inst. Wash., Publ. 366, p. 141 [compared with *C. (F.) elattocostatum* Woodring]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 140 [in part], pl. 23, fig. 13 [referred to "Section" *Fragum* s.s.; "Type locality: No. 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla."].

Trigoniocardia (Americardia) burnsii (Dall). STEWART, 1930, Acad. Nat. Sci. Phila., Spec. Publ. 3, p. 268.

Trigoniocardia (Americardia?) burnsi (Dall). GLIBERT and VAN DE POEL, 1970, Inst. Roy. Sci. Nat. Belg., Mém., ser. 2, fasc. 84, p. 60 ["Miocene (Chipola). Oak Grove (Floride, U.S.A.)"].

It seems quite certain that Dall included two forms in his original description of this species; that represented by the holotype is here discussed, the other is formally described as *T. (Americardia) decidua,* n. sp. As may be noted in Table 6, the number of ribs on the valve as given in the Dall description — 22 to 24 on the area anterior to the postero-ventral angulation and 12 to 14 posterior to it — agrees more closely with the number present in typical examples of *T. (A.) decidua,* but the nodose condition of intritacalx ornamentation on the holotype fixes the name on the form that also proves to be the more widespread and abundantly represented of the two species concerned.

As also noted above, the characters of the hinge of *T. burnsii* tend to vary between those considered distinctive of the modern species of *Trigoniocardia* and those of *Americardia,* especially as concerns the relative position of the anterior lateral teeth with respect to the cardinals. This combination of features characteristic of the two subgenera has made it difficult to distinguish between specimens of *T. burnsii* and *T. decidua* when the intritacalx has been eroded away. The rib counts, as shown in Table 6, overlap to some degree; accordingly, no firm reliance can be placed upon this feature. As

TABLE 6

Number of radial ribs:

Localities of specimens of *T. (T.) burnsii*	Anterior surface 17	18	19	20	21	22	23	24	Posterior surface 9	10	11	12	13	14	Valves counted:
TU 458, Chipola River	—	2	6	9	4	4	–	—	1	7	10	7	—	—	25
TU 830, Tenmile Creek	2	4	8	9	1	1	—	—	—	5	17	3	—	—	25
TU 825, Farley Creek	1	5	7	10	2	—	—	—	—	8	13	3	1	—	25
Total - *burnsii* —	3	11	21	28	7	5	0	0	1	20	40	13	1	0	75
T. (A.) decidua —	0	0	0	1	6	15	22	6	0	0	6	26	15	3	50

a result, the statistics as to the number and percentages of these species present in the collections from the various Chipola localities (see Table 2), cannot be considered as wholly definitive. This is particularly true for the collections from Farley Creek localities where the average sediment size is somewhat more coarse-grained than is typical of that from the Chipola River and Tenmile Creek areas. Presumably this coarser sediment size reflects a somewhat higher-energy type of environment and hence probably greater bottom sediment movement. This combination seems have been the cause of the observable fact that there is a considerably larger percentage of surficially worn and abraded specimens in these collections than are to be found in those from the other areas. These have been assigned in the table on the basis of rib counts and hinge characteristics, even though as noted above, these are known to be variable and hence unreliable, for they are the only available characters preserved. Accordingly, it is possible that the actual number of specimens of *T. burnsii* in the Farley Creek collections is higher, and the number of *T. decidua* lower, than is given in the table.

As was also true of *T. simrothi,* the citation by Glibert and Van de Poel (1970, p. 60) of *T. burnsii* as an Oak Grove species is almost certainly erroneous. It is not listed as from that locality by either Dall or Gardner and no remotely similar species is seen in the Tulane University Oak Grove collections.

Figured specimen, USNM 243540; height 8.2 mm, length 7.5 mm, diameter (right valve) 3.1 mm; locality TU 546 (Pl. 8, fig. 1).

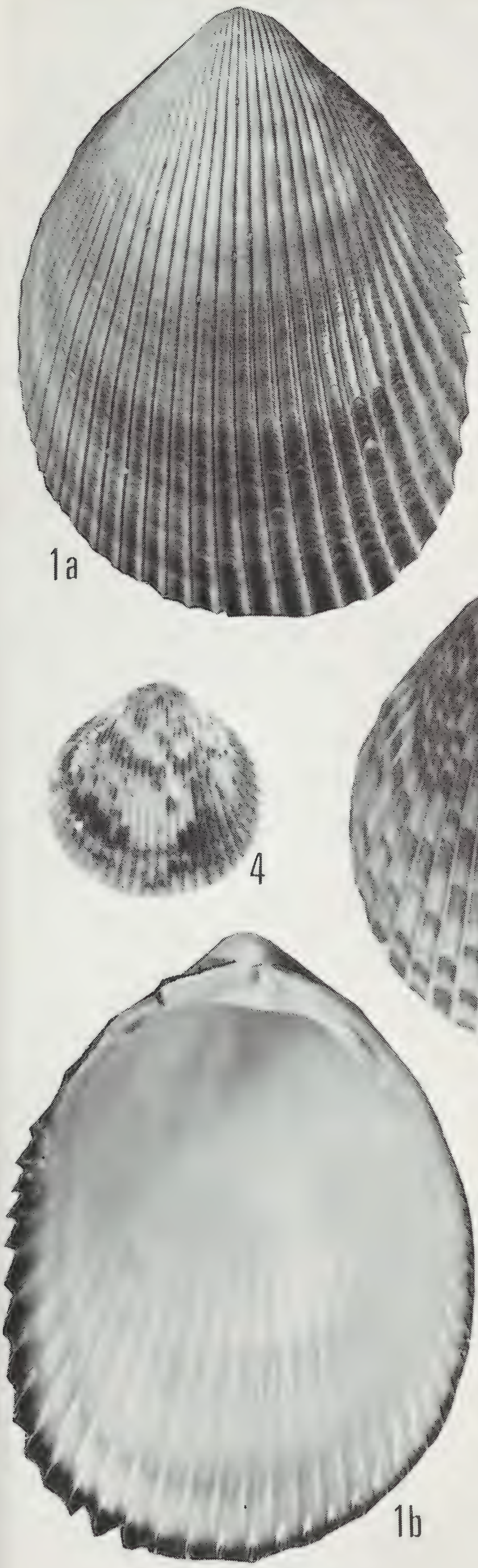
Figured specimen, USNM 243541; height 7.4 mm, length 7.0 mm, diameter (left valve) 2.8 mm; locality TU 830 (Pl. 6, fig. 3; Pl. 8, fig. 2).

Figured specimen, USNM 243542; height 6.8 mm, length 6.5 mm, diameter (right valve) 2.7 mm; locality TU 830 (Pl. 8, fig. 3).

PLATE 10

Figures Page

1. *Acrosterigma (Vasticardium) elongatum* (Bruguière) 161
   Figured specimen, USNM 711239 (X .75); height 91.0 mm, length 68.4 mm, diameter (paired valves) 52.5 mm. Exterior and interior of left valve.
   Locality: Calitupan Island, Bohol, Philippines; Recent.
2. *Acrosterigma (Vasticardium) hoerleorum* H. E. Vokes, n. sp. 162
   Paratype E, USNM 243560 (X 1.5); height 45.9 mm, length 38.4 mm. Exterior and interior of right valve.
   Locality: TU 830, Tenmile Creek.
   Note: Compare the ultraviolet light color pattern of *A. (V.) hoerleorum* with that of the Recent *A. (V.) elongatum,* type of the subgenus. The broad external color bands of the Recent species are of a reddish tint as are the darkly colored denticulate internal margins. Note the difference between these patterns and that of the Pliocene *Acrosterigma dalli,* type of the genus.
3. *Acrosterigma (Acrosterigma) dalli* (Heilprin) 160
   Figured specimen, USNM 243564 (X .9); height 64.2 mm, length 51.3 mm, diameter (left valve) 17.8 mm. Color pattern as revealed by ultraviolet light.
   Locality: TU 529, Caloosahatchee Formation, Caloosahatchee River, Florida.
4, 5. *"Trachycardium" virile* (Dall) 154
   4. Figured specimen, USNM 243561 (X 1.5); height 17.8 mm, length 17.3 mm.
      Locality: TU 830, Tenmile Creek.
   5. Figured specimen, USNM 243562 (X 1.5); height 22.2 mm, length 20.1 mm.
      Locality: TU 546, Tenmile Creek.
      Color patterns as revealed by ultraviolet light.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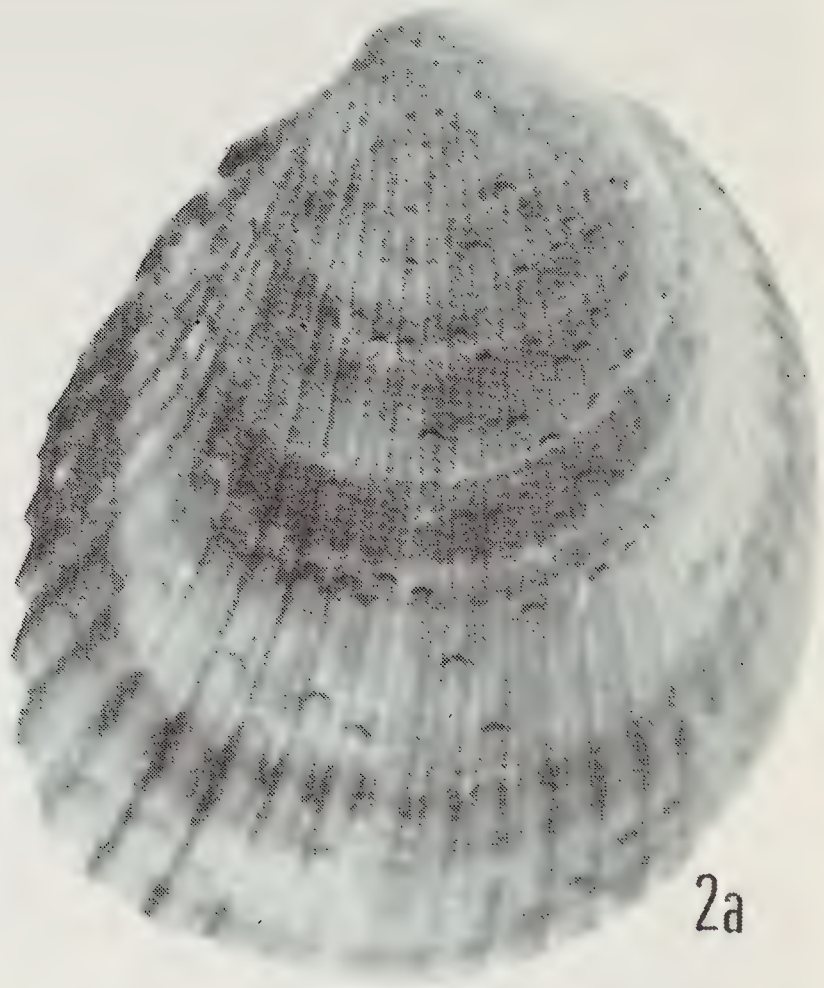
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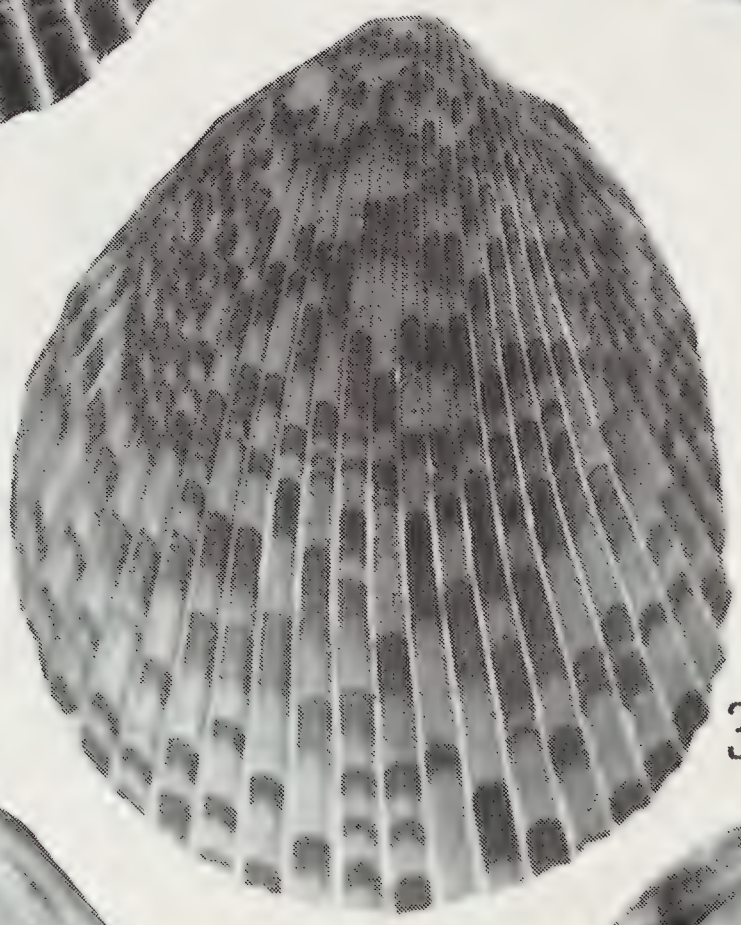
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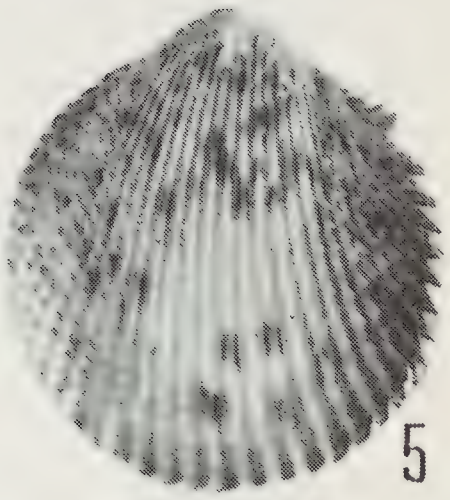
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1b

2b

PLATE 10

Subgenus AMERICARDIA Stewart, 1930

Americardia STEWART, 1930, Acad. Nat. Sci., Phila., Spec. Publ. 3, pp. 37, 267.

Type species, by original designation, *Cardium medium* Linnaeus, 1758. Recent; North Carolina, the West Indies and Caribbean Sea southward to Bahia and Trindade Isl., Brazil.

The characters that serve to distinguish *Americardia* from the typical forms of *Trigoniocardia* have been noted in the discussion of the latter group.

TRIGONIOCARDIA (AMERICARDIA) DECIDUA H. E. Vokes, n. sp.

Plate 6, figure 4; Plate 8, figures 4-6

Cardium (Fragum) Burnsii DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1101 [in part].

Diagnosis: Shell relatively small, subquadrate, moderately inflated, on the average slightly more inflated than typical specimens of *T. burnsii* and noticeably less so than those of *T. simrothi.* Anterior margin broadly convex, almost straight, broadly rounding antero-ventrally into the slightly arched ventral margin, which, in turn, is strongly angulate into the concave posterior end; the angulate postero-ventral margin being the result of a well-developed obtuse angulation of the valve surface, and the posterior concavity marking the end of a median depression that traverses the median portion of the posterior end. Surface of valve ornamented by strong radial ribs with 20 to 24 ribs (usually 22 or 23) on and anterior to, the postero-ventral angulation and with 11 to 14 (usually 12 or 13) on the posterior slope; ribs separated by much narrower interspaces. Intritacalx on unworn specimens (see Pl. 6, fig. 4) consisting of arched concentric threads certain of which are more strongly developed, simulating nodes. Much variation in the details of the intritacalx in this species (see discussion of the genus *Trigoniocardia* above). The arcuate concentric threads tend to extend laterally beyond the crests of the ribs, giving the inter-rib areas an almost linear appearance. With the intritacalx eroded away, the interspaces prove to be approximately one-fourth the width of the adjacent ribs, showing a well-developed ladder-like pattern of low transverse lamellae that appear to be the remnant bases of the transverse intritacalx structures; the rib tops, however, then appearing wholly smooth. Internal margins fluted, with raised denticulations marking the inter-rib areas. Hinge normal for the subgenus *Americardia,* with the anterior lateral teeth moderately distant from the cardinals, although not as distant as are the posterior laterals.

Holotype, USNM 243543; height 12.3 mm, length 11.6 mm, diameter (right valve) 5.1 mm; locality TU 546 (Pl. 6, fig. 4; Pl. 8, fig. 4).

Paratype A, USNM 243544; height 11.6 mm, length 11.8 mm, diameter (right valve) 4.7 mm; locality TU 830 (Pl. 8, fig. 5).

Paratype B, USNM 243545; height 15.6 mm, length 15.0 mm, diameter (right valve) 6.3 mm; locality TU 830 (Pl. 8, fig. 6).

Discussion: Trigoniocardia (Americardia) decidua suggests a small version of *T. (A.) media* (Linnaeus), differing primarily in the details of its intritacalx ornament and the lesser number of radial ribs on the surface anterior to the postero-ventral angulation. As noted above in the discussion of *T. burnsii* (Dall), specimens of *T. burnsii* and *T. decidua* lacking the intritacalx are difficult to separate, although fully adult specimens of *T. decidua* tend to attain dimensions almost twice those of *burnsii,* and in these large forms the median groove and the consequent marginal insinuation of the posterior end are notably stronger than is ever attained on specimens of *T. burnsii.* Paratype B, USNM 243545, is the largest of the 1135 specimens present in the Tulane collections.

Subfamily LAEVICARDIINAE Keen, 1936
Genus LAEVICARDIUM Swainson, 1840

Laevicardium SWAINSON, 1840, Treatise on Malacology, p. 373.

Type species, by subsequent designation, Stoliczka, 1871, *Cardium oblongum* Gmelin. Recent; Mediterranean and Adriatic Seas.

The ribbing on the median and anterior portion of the valves of *L. oblongum* is more strongly developed than it is on the majority of the species usually referred to this genus. *Laevicardium laevigatum* (Linnaeus), selected as type by Herrmannsen (1847, p. 571) and by Gray (1847, p. 185), is more representative of the usual form, but unfortunately was not originally included by Swainson in his description of the genus. The absence of *C. laevigatum* and the inclusion of *C. oblongum* seems inexplicable in the light of Swainson's statement that the surface of the shell of *Laevicardium* is "neither ribbed nor spired [sic]."

LAEVICARDIUM COMPRESSUM (Dall)
Plate 8, figure 7; Plate 9, figure 2

Cardium (Laevicardium) compressum DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1109;1903, *ibid.*, v. 3, pt. 6, pl. 48, fig. 21; SCHUCHERT *et al.*, 1905, U.S. Nat. Mus., Bull. 53, p. 129 [Holotype, USNM 114769; "Oligocene, Calhoun County, Florida"]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 142, pl. 23, fig. 16 ["Type locality: No. 2213; 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla."].

Dall's specific name for this form is in allusion to the posterior area being "compressed so that the pinch gives to the posterior margin a distinct insinuation." Examination of a large number of specimens (364 from TU 458) reveals that this is a highly variable character with the form illustrated by Dall as an extreme. Approximately fifty per cent of the specimens show no marginal reflection of any compression, and in the vast majority of the forms in which it is to be noted it is marked solely by a slight straightening of the generally broad margin curvature; a typical example of this expression is shown on pl. 8, fig. 7.

This species, like *Dinocardium chipolanum,* is widely distributed in all facies of the Chipola Formation and generally is present in considerable numbers, although there are only about one-half as many valves of *L. compressum* as there are of *D. chipolanum* in the Tulane collections.

Figured specimen, USNM 243546; height 21.8 mm, length 20.8 mm, diameter (right valve) 7.5 mm; locality TU 458 (Pl. 8, fig. 7).

Figured specimen, USNM 243552; height 20.4 mm, length 19.7 mm, diameter (left valve) 6.8 mm; locality TU 950 (Pl. 9, fig. 2a).

Figured specimen, USNM 243553; height 22.0 mm, length 20.7 mm, diameter (left valve) 6.5 mm; locality TU 950 (Pl. 9, fig. 2b).

Genus DINOCARDIUM Dall, 1900

Dinocardium DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1074 [as "section" of "subgenus" *Cerastoderma* Mörch].

Exocardium OLSSON, 1964, Neogene Mollusks from Northwestern Ecuador, p. 55 [type species by original designation, *Cardium (Dinocardium) ecuadorialis* Olsson, 1932].

Type species, by original designation, "*Cardium magnum* Born = *C. ventricosum* Brug." [= *C. robustum* Lightfoot *in* Solander, 1786]. Recent; Cape May, New Jersey, to west and north coasts of the Yucatán Peninsula to Isla Contoy, but apparently not present on the eastern Caribbean coast.

Dall's citation of *Cardium magnum* Born as type of his new "section" of *Cerastoderma* was apparently a *lapsus* inasmuch as he included both the Born and Bruguière species in the synonymy of his "*Cardium*" *(Cerastoderma) robustum* Solander" on p. 1099 of the same work.

Olsson (1964, p. 55) referred *D. chipolanum* to his subgenus *Exocardium* which he defined, in part, as having the posterior area "generally smooth and polished, without ribbing." Although the ribbing on the Chipola species is somewhat subdued it is nevertheless definitely present and on immature forms is almost as strongly developed as it is on the more anterior areas of the valve. The writer believes that the Ecuadorian species is at best an end-variant of the *Dinocardium* tendency toward reduction of the posterior ribbing, a feature well shown in the type species of that genus.

DINOCARDIUM CHIPOLANUM (Dall)
Plate 8, figures 8-10; Plate 9, figure 8

Cardium (Cerastoderma) chipolanum DALL, 1900, Wagner Free Inst. Sci., Trans., v. 3, pt. 5, p. 1098, pl. 40, fig. 8; SCHUCHERT *et al.*, 1905, U. S. Natl. Mus., Bull. 53, p. 129 [Holotype, USNM 114765; "Oligocene. Chipola River, Florida"]; GARDNER, 1926, U. S. Geol. Surv. Prof. Paper 142-C, p. 138, pl. 23, fig. 9 ["Type locality: No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Chipola River, Calhoun County, Fla."].

Dinocardium (Exocardium) chipolanum Dall. OLSSON, 1964, Neogene Mollusks from Northwestern Ecuador, p. 55.

Cerastoderma (s.s.) *chipolanum* (Dall). GLIBERT and VAN DE POEL, 1970, Inst. Roy. Sci. Nat. Belg., Mém., ser. 2, fasc. 84, p. 40.

Although Dall *in* Schuchert *et al.* (1905, p. 129) cites the type locality for this species as "Chipola River, Florida," Gardner (1926, p. 138) states that the type was from locality "No. 2212, Tenmile Creek, 1 mile west of Baileys Ferry, Chipola River, Calhoun County, Fla."

As aptly noted by Dall, this species "is a miniature *Cardium robustum,* and is especially characteristic of the Chipola horizon." It occurs at all Tulane University localities from which more than a very few specimens were collected, the sole exceptions being TU 550, and TU 807, an *Ostrea/Spondylus* reef facies on the Chipola River. This is the only suggestion of facies control in its distribution for it otherwise is present in the open-water, coral reef and back-reef or lagoonal (?) facies. It is almost always one of the more abundantly represented species at any locality. For example, there are more than 800 valves in the collections from TU 546, which so far as we can determine, is the same as USGS locality 2212, cited by Gardner as type locality.

The "subspecies" *alumen* described by Gardner (1926, p. 138, pl. 32, fig. 6) from the Alum Bluff Chipola strata occurs with the more typical form at almost all Chipola localities. At best, it is no more than a variety; its dominance at Alum Bluff may suggest some ecologic control factor. The sediment at that locality seems to be more coarse-grained and to have a higher quartzose sand and lower lime content than that of the Chipola River exposures; it may represent more shallow-water deposition.

The largest specimen noted in the collections, a left valve from locality TU 458, has a height of 50.3 mm, a length of 49.1 mm, and a diameter of 17.8 mm.

Figured specimen, USNM 243547; height 30.5 mm, length 30.3 mm, diameter (paired valves) 23.2 mm; locality TU 458 (Pl. 8, fig. 8).

Figured specimen, USNM 243548; height 33.6 mm, length 33.5 mm, diameter (left valve) 13.1 mm; locality TU 458 (Pl. 8, fig. 9).

Figured specimen, USNM 243549; height 45.7 mm, length 44.3 mm, diameter (left valve) 16.0 mm; locality TU 827 (Pl. 8, fig. 10).

Figured specimen, USNM 243554; height 39.8 mm, length 38.3 mm, diameter (right valve) 14.6 mm; locality TU 825 (Pl. 9, fig. 8).

VII. LOCALITY DATA

The following Tulane University fossil localities in the Chipola Formation, Calhoun County, Florida, have yielded specimens referrable to the family Cardiidae:

70. Tenmile Creek, north bank at bridge of Florida Highway 73 (NW ¼ Sec. 12, T1N, R10W).
196. Tenmile Creek, north bank ca. 0.25 mile upstream from TU 70 (NE ¼ Sec. 12, T1N, R10W).
456. Tenmile Creek, north bank ca. 0.25 mile downstream from TU 70 (NW ¼ Sec. 12, T1N, R10W).
457. Chipola River, west bank ca. 0.5 mile downstream from mouth of Tenmile Creek (SW ¼ Sec. 17, T1N, R10W).
458. Chipola River, east bank ca. 0.3 mile upstream from mouth of Farley Creek (SW ¼ Sec. 20, T1N, R9W).
459. Chipola River, east bank about 1500 feet upstream from mouth of Taylor Lake Branch (NW ¼ Sec. 29, T1N, R9W).
546. Tenmile Creek, north bank 1.75 miles west northwest of mouth of creek at Bailey's Ferry (SW ¼ NE ¼ Sec. 12, T1N, R10W).
547. Chipola River, west bank about 2000 feet upstream from mouth of Fourmile Creek (SW ¼ Sec. 29, T1N, R9W).
548. Chipola River, west bank at bend about 1800 feet downstream from mouth of Farley Creek (NW ¼ Sec. 29, T1N, R9W).
549. Chipola River, east bank ca. 0.25 mile below mouth of Fourmile Creek (NE ¼ Sec. 20, T1N, R9W).
550. Chipola River, east bank 1.25 miles below mouth of Tenmile Creek (NE ¼ Sec. 20, T1N, R9W).
551. Chipola River, east bank ca. 0.5 mile below mouth of Fourmile Creek (NE ¼ Sec. 32, T1N, R9W).
552. Chipola River, east bank ca. 1.5 miles downstream from mouth of Tenmile Creek (NE ¼ Sec. 20, T1N, R9W).
553. Chipola River, east bank at mouth of Farley Creek (SW ¼ Sec. 20, T1N, R9W).
554. Chipola River, east bank immediately downstream from power line crossing (SW ¼ Sec. 17, T1N, R9W).
555. Chipola River, east bank about 1000 feet above mouth of Fourmile Creek (SW ¼ Sec. 29, T1N, R9W).
655. Tenmile Creek, north bank ca. 0.1 mile downstream from TU 70 (NW ¼ Sec. 12, T1N, R10W).
708. Small waterfall on tributary entering Tenmile Creek from south ca. 0.25 mile downstream from TU 70 (NW ¼ Sec. 12, T1N, R10W).
709. Tenmile Creek, south bank ca. 0.25 mile downstream from TU 70 (NW ¼ Sec. 12, T1N, R10W).

710. Tenmile Creek, south bank between mouth of Mayo's Mill Branch and unnamed stream 1000 feet upstream (NW ¼ Sec. 11, T1N, R10W).
711. Chipola River, west bank ca. 0.25 mile upstream from mouth of Farley Creek (SW ¼ Sec. 20, T1N, R9W).
786. Tenmile Creek, north bank about 50 yards upstream from TU 196 (NE ¼ Sec. 11, T1N, R10W).
787. Tenmile Creek, south bank ca. 1.5 miles west northwest of mouth of creek at Bailey's Ferry (SW ¼ Sec. 12, T1N, R10W).
806. Chipola River, west bank ca. 0.5 mile below powerline crossing at TU 554 (NW ¼ Sec. 20, T1N, R9W).
807. Chipola River, west bank 0.25 mile downstream from powerline crossing at TU 554 (NE ¼ NW ¼ Sec. 20, T1N, R9W).
810. Chipola River, east bank ca. 0.25 mile below Bailey's Ferry (NW ¼ SW ¼ Sec. 17, T1N, R9W).
817. Mouth of large gully entering Tenmile Creek from south side (Center SE ¼ Sec. 12, T1N, R10W).
818. Farley Creek, south bank 0.1 mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
819. Farley Creek, south bank 0.2 mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
820. Farley Creek, north bank immediately upstream from bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
821. Farley Creek, north bank 0.1 mile east of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
822. Farley Creek, south bank 0.25 miles east of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
823. Farley Creek, south bank ca. 2000 feet east of bridge of Florida Highway 275 (SE ¼ Sec. 21, T1N, R9W).
824. Farley Creek, north bank ca. 0.5 mile east of bridge of Florida Highway 275 (SE ¼ Sec. 21, T1N, R9W).
825. Farley Creek, north bank at abandoned mill ca. 0.25 mile west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W).
826. Farley Creek, north bank ca. 0.1 mile west of TU 825 (on line between Sec. 20 & 21, T1N, R9W).
827. Farley Creek, south bank ca. 0.5 mile west of bridge of Florida Highway 275 (SE ¼ Sec. 20, T1N, R9W).
828. Farley Creek, south bank immediately upstream from unnamed tributary entering from north ca. 0.75 mile west of bridge on Florida Highway 275 (SE ¼ Sec. 20, T1N, R9W).
829. Unnamed tributary entering Farley Creek from north near TU 828, west bank about 200' above confluence (SE ¼ Sec. 20, T1N, R9W).
830. Tenmile Creek, north bank at power line crossing, ca. 1.3 miles west northwest of mouth of creek at Bailey's Ferry (SE ¼ SE ¼ Sec. 12, T1N, R10W).
831. Tenmile Creek, north bank 1.1 miles west northwest of mouth of creek at Bailey's Ferry (SW ¼ SW ¼ Sec. 7, T1N, R9W).
949. Chipola River, west bank ca. 0.1 mile downstream from power line crossing (SW ¼ Sec. 17, T1N, R9W).
950. Chipola River, west bank ca. 200 feet above mouth of Farley Creek (NE ¼ SW ¼ Sec. 20, T1N, R9W).
951. Tenmile Creek, south bank ca. 1.5 miles west northwest of mouth of creek at Bailey's Ferry (SE ¼ Sec. 12, T1N, R10W).
998. Tenmile Creek, north bank ca. 1.6 miles west northwest of mouth of creek at Bailey's Ferry (NW ¼ SE ¼ Sec. 12, T1N, R10W).
999. Farley Creek, south bank ca. 900 feet west of bridge on Florida Highway 275 (SW ¼ SW ¼ Sec. 21, T1N, R9W).
1019. Chipola River, east bank 0.3 miles downstream from power line crossing (NE ¼ NW ¼ Sec. 20, T1N, R9W).
1020. Chipola River, east side at mouth of small tributary (not shown on USGS topographic map) ca. 0.5 mile downstream from power line crossing (near W side NE ¼ Sec. 20, T1N, R9W).
1021. Tenmile Creek, north bank at north end of first meander upstream from TU 546, ca. 0.45 mile east of bridge on Florida Highway 73 (SE ¼ NW ¼ Sec. 12, T1N, R9W).
1047. Chipola River, west bank 0.1 mile downstream from mouth of Farley Creek (SE ¼ SW ¼ Sec. 20, T1N, R9W).
1048. Farley Creek, south bank ca. 0.6 mile east of bridge on Florida Highway 275 (SW ¼ NE ¼ Sec. 21, T1N, R9W).
1049. Farley Creek, south bank ca. 1.0 mile east of bridge on Florida Highway 275 (NE ¼ NE ¼ Sec. 21, T1N, R9W).
1050. Chipola River, west bank at powerline crossing (SW ¼ Sec. 17, T1N, R9W).
1051. Tenmile Creek, south bank just downstream from TU 817 (SE ¼ Sec. 12, T1N, R10W).
1052. Tenmile Creek, north bank, immediately upstream from large, dry meander cut-off (SE ¼ Sec. 12, T1N, R10W).
1097. Tenmile Creek, south bank of cut-off meander, ca. 500 yards east of Florida Highway 73 (SW ¼ NW ¼ Sec.12, T1N, R10W).
1098. Tenmile Creek, south bank just east of power line crossing (SE ¼ SE ¼ Sec. 12, T1N, R10W).
1196. Farley Creek, north bank ca. 0.65 mile east of bridge on Florida Highway 275 (SW ¼ NE ¼ Sec. 29, T1N, R9W).

Localities mentioned in this report that are not from the type area of the Chipola Formation in Calhoun County:

201. Spoil banks at pit (now abandoned) just south of Belle Glade, at Belle Glade Camp, Palm Beach County, Florida. Bermont Formation.
453. Alum Bluff, Apalachicola River, Liberty County, Florida (NE ¼ Sec. 24, T1N, R8W). Locality is in "lower beds." Chipola Formation.
529. Caloosahatchee River, north bank about 3 miles downstream from La Belle, Hendry County, Florida. Caloosahatchee Formation.
953. Moín Hill, Costa Rica; railroad cut and ditches adjacent to road to Sandoval. Locality is 4.5 kilometers west of Puerto Limon. Moín Formation.
954. Hill cut immediately behind Standard Fruit Co. box factory and just west of cemetery at Pueblo Nuevo and ca. 2 kms west of Puerto Limon, Costa Rica. Moin Formation.
1145. Boynton Landing, east bank of Choctawatchee River, just above Boynton Cut-Off (which connects Choctawhatchee River and Holmes Creek), (SE ¼ Sec. 31, T2N, R16W), Washington Co., Florida. Chipola Formation.
R-109. Material dredged from Bahia de las Minas at Isla Payardi, Dist. de Colon, Atlantic Coast of Panamá. Recent.
R-186. Beach and immediately offshore at leper colony, Palo Seco, Canal Zone, Panamá. Recent.

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REVIEWS

THE CORAL REEF PROBLEM, by William Morris Davis, a reprint of the 1928 edition, with an introduction by Albert V. Carozzi. Published by Robert E. Krieger Publishing Company, Huntington, New York, 1976, xvi + 596 pp., illus.

William Morris Davis became interested in coral reefs in 1868 while a student in N. S. Shaler's geology class at Harvard. Much later, after Davis became renowned as a geomorphologist, he retired early from Harvard University (1912) and devoted fully fifteen years to a complete geomorphological analysis of coral reefs. His classic study was published in 1928, reaffirming the Darwinian concepts of intermittently subsiding islands with fringing reefs developing ultimately into complex atolls. He produced his own all-encompassing theory of coral reef development, relating many apparently unrelated and contradictory facts about coral reefs into his refinement of the subsidence theory, tempered with limited acceptance of glacial-control of certain features in marginal reef belts. This work is of fundamental importance to geological theory.

FOSSILS AND PROGRESS: Paleontology and the Idea of Progressive Evolution in the Nineteenth Century, by Peter J. Bowler. Published by Science History Publications, New York, 1976, viii + 191 pp., $9.95

This volume is concerned with the apparent progressive development of life, through earth history, from the simplest to the most complex forms, and the role of this crucial observation, the concept of "progression", in the mid-nineteenth century debates over evolutionary theory. Among those whose ideas are treated in some depth are Georges Cuvier, Adolphe Brongniart, Geoffroy Saint Hilaire, Louis Agassiz, Robert Chambers, Charles Darwin, and Charles Lyell. The text treats the origin and development of "progressionism" as a concept, its opponents and their arguments, the complications introduced by recognition of divergence and the weakening of the concept of linear evolution, and concludes with an analysis titled "Darwinism and Progression". It provides intriguing additional insight into the history of evolutionism.

—H.C.S.

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION—XXI
A NEW SPECIES OF THE GENUS *LOPHA* (MOLLUSCA:BIVALVIA)

HAROLD E. VOKES
TULANE UNIVERSITY

The shallower water deposits of the Chipola Formation exposed in the section along Farley Creek eastward from the Chipola River contain many specimens of a relatively small species of the ostreid genus *Lopha.* All are elongate and most show evidence that they were attached, during life, to a tubular dasycladacian alga that is common in all collections from that area; a few, however, were attached to small cerithioid and *Turritella* shells.

Genus LOPHA Röding, 1798

Type species (by subsequent designation, Dall, 1898): *Mytilus cristagalli* Linnaeus, 1758. Recent, tropical Indo-Pacific.

Stenzel, in discussing the genus *Lopha* in the *Treatise on Invertebrate Paleontology* (1971, Part N, vol. 3, p. N1157), recognizes two "ecomorphs" of very different external appearance that result from differing habits of growth. One, typified by the type species of the genus, has both valves convex and equivalved, and is globular to irregularly rounded in shape with a few deep plications. It is generally found growing on mangroves or on the shells of other bivalves. The second ecomorph, of which the present species is an example, lives somewhat more offshore than the first and attaches, in the recent species, primarily to stems of sea fans and other Gorgonians, although we have in the Tulane collections a number that were attached to slender branching corals. It tends to be elongate-ovate to lanceolate in outline, and to have the valves outside of the area of attachment marked by relatively numerous radial plications with, on the upper (right) valve a tendency to develop a rounded, longitudinal ridge extending the length of the valve, in a position corresponding to the concave trough on the left valve that resulted from the surface of attachment. In the past, the species referred to this ecomorph were assigned to the genus *Dendostrea* Swainson, 1835 (type, *Ostrea folium* Linnaeus, 1758).

LOPHA FRONDICULA H. E. Vokes, n. sp.
Text figures 1-8

Description: Shell small, attached by the left valve, which is somewhat more convex than the right, elongate-ovate to lanceolate in outline, with, however, the anterior margin tending to be more produced and rounded than the posterior. Two differing variations represented, apparently reflecting differences in the width of the algal "stem" to which they attached. In those forms fixed to a slender dasycladacian tube the left valve, outside of the attachment groove, ornamented by numerous (25 to 40) low, rounded ribs that plicate the shell only in the marginal area, external to the pallial line; the upper, right valve but weakly ornamented, almost smooth, with thickened marginal denticulations fitted into the plicate folds. Forms with a broader attachment area tending to have fewer (about 20) stronger folds that plicate both valves from the outer margin to a point inside of the pallial line. Specimens of the former type narrower and more lanceolate in profile than those more ovate forms attached to a broader surface; the former almost always smaller than the more strongly plicate forms, perhaps because their weight causes the thin tubes to break off and fall, along with their attached shells, into the entombing sediment. Ligamental area subtriangular in outline, usually somewhat oblique with a moderately broad median depression deeper in the left valve than in the right. Margins of the right valve adjacent to the area raised to form narrow elongate ridges, received almost as crural ridges in grooves in the margin of the area of the left. Muscle scar moderately large and elongate to sub-elliptical in outline. Valve margins obscurely and minutely pustulate but the surface inside of the pallial line apparently smooth.

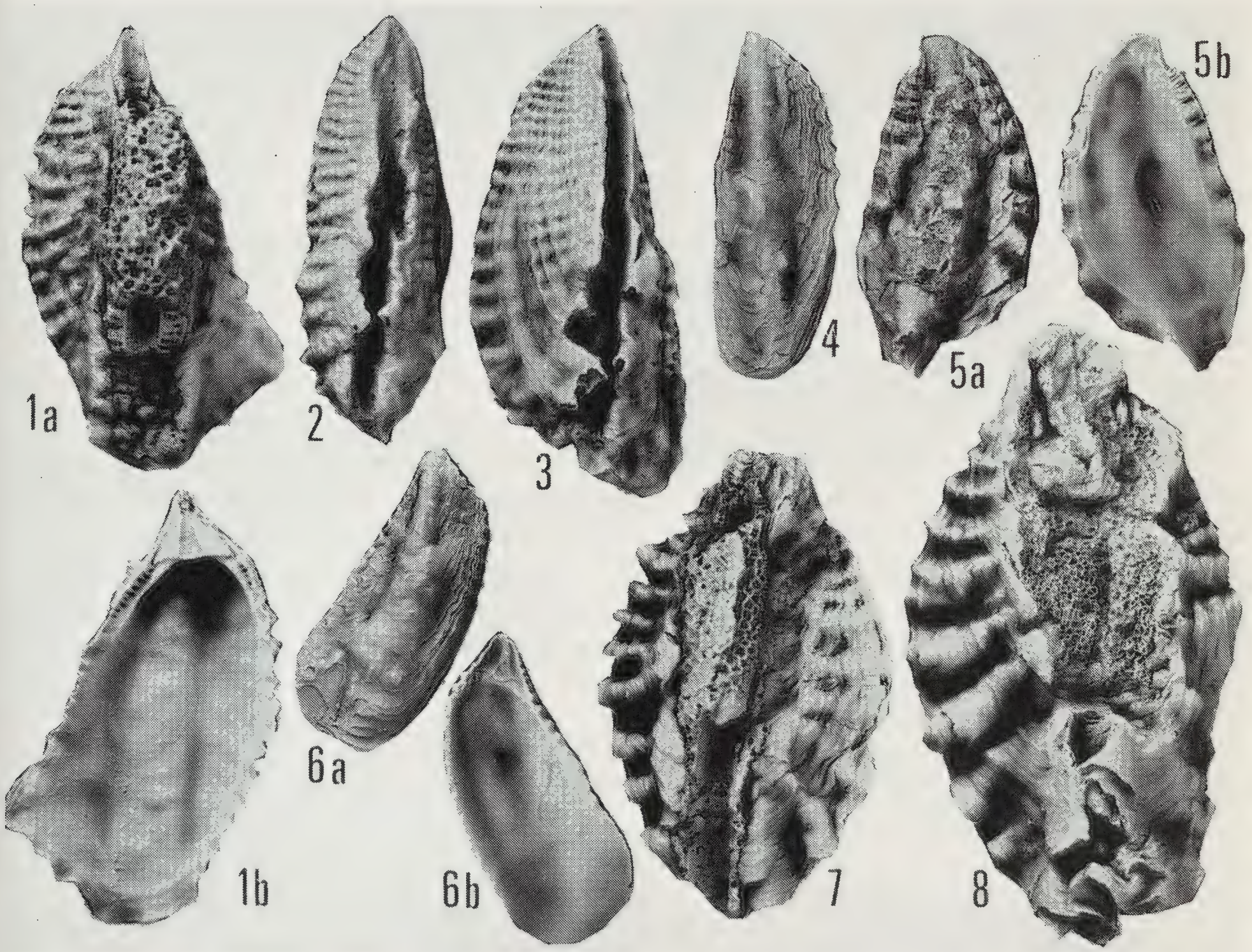
Type locality: TU 999, Farley Creek, about 900 feet west of bridge of Florida Highway 275 (SW ¼ Sec. 21, T1N, R9W), Calhoun County, Florida.

Remarks: The vast majority of the specimens of this new species in the Tulane collections represent the lanceolate form, the broader ovate type being relatively rare. They differ from the Recent warm-water western Atlantic *Lopha frons* (Linnaeus, 1758) in the much smaller size, and more abundant plications and/or costae. *"Ostrea (Lopha)" folioides* Woodring (1925, p. 61, pl. 7, figs. 3-5) from the Bowden Formation of Jamaica is also larger and differs in having

the plications only on the margin with the central part of the shell almost smooth.

(For bibliographic references and locality descriptions see preceding paper.)

November 16, 1977



Text figures:

1. USNM 248185, Holotype (left valve); height 23.3 mm, length 13.8 mm, diameter 5.1 mm; locality TU 999.
2. USNM 248186, Paratype (left valve); height 22.2 mm, length 7.6 mm, diameter 3.7 mm; locality TU 826.
3. USNM 248187, Paratype (left valve); height 24.0 mm, length 10.8 mm, diameter 3.6 mm; locality TU 1048.
4. USNM 248188, Paratype (right valve); height 18.2 mm, length 6.6 mm, diameter 2.7 mm; locality TU 1048.
5. USNM 248189, Paratype (right valve); height 17.7 mm, length 9.0 mm, diameter 4.0 mm; locality TU 818.
6. USNM 248190, Paratype (right valve); height 16.3 mm, length 7.3 mm, diameter 2.2 mm; locality TU 820.
7. USNM 248191, Paratype (left valve); height 24.5 mm, length 15.3 mm, diameter 5.5 mm; locality TU 820.
8. USNM 248192, Paratype (left valve); height 32.6 mm, length 18.1 mm, diameter 6.8 mm, locality TU 826.

(All figures magnified X 2)

A SECOND WESTERN ATLANTIC SPECIES OF *VITULARIA* (MOLLUSCA:GASTROPODA)

EMILY H. VOKES
TULANE UNIVERSITY

In 1967 the writer reported the occurrence of the gastropod *Vitularia* in the Pinecrest Beds of southern Florida. This marked the first knowledge of the genus in the western Atlantic fauna, the only previously known New World species being from the eastern Pacific. Consequently, it was with great delight that a second western Atlantic species was recognized in collections made during the Summer, 1976, in the Gurabo Formation of the Dominican Republic.

Although the Tertiary molluscan fauna of the island of Hispaniola (Santo Domingo) has been known since G. B. Sowerby described several new species in 1850, little paleontologic work has followed, the major exception being the Maury expedition of 1916 (Maury, 1917). This is, in large measure, due to the more or less permanent state of political unrest that until recently plagued that area. But over the last ten years the government has achieved a stable condition to the point that the Dominicans are actively soliciting tourist business. Certainly our visit was a vast improvement over the one described by Maury during which the party was harassed by revolutionaries, slept in hen houses and suffered all manner of deprivation. Perhaps this explains why we found a large number of undescribed forms, which will be dealt with in future papers.

The genus *Vitularia* first occurs in the Oligocene of France, with the species *V. linguabovis* (Basterot, 1825), the only Old World fossil form, which persisted up through the middle Miocene of the Aquitaine and Vienna basins. The oldest reported occurrence in the New World is *V. equadorana* Marks, 1951, described from the middle Miocene Daule Formation of Equador. However, this assignment was determined by comparison with the fauna of the "middle Miocene" Gatun Formation of Panamá and the upper beds of the Tuberá Group of Colombia. These units are at least upper Miocene, if not lower Pliocene in age, so that *V. equadorana* is probably not as old as formerly believed. The only other occurrences in the New World are the living West Coast *V. salebrosa* (King and Broderip, 1832) and a similar form in the Pliocene Charco Azul Formation of western Costa Rica (Olsson, 1942, p. 170).

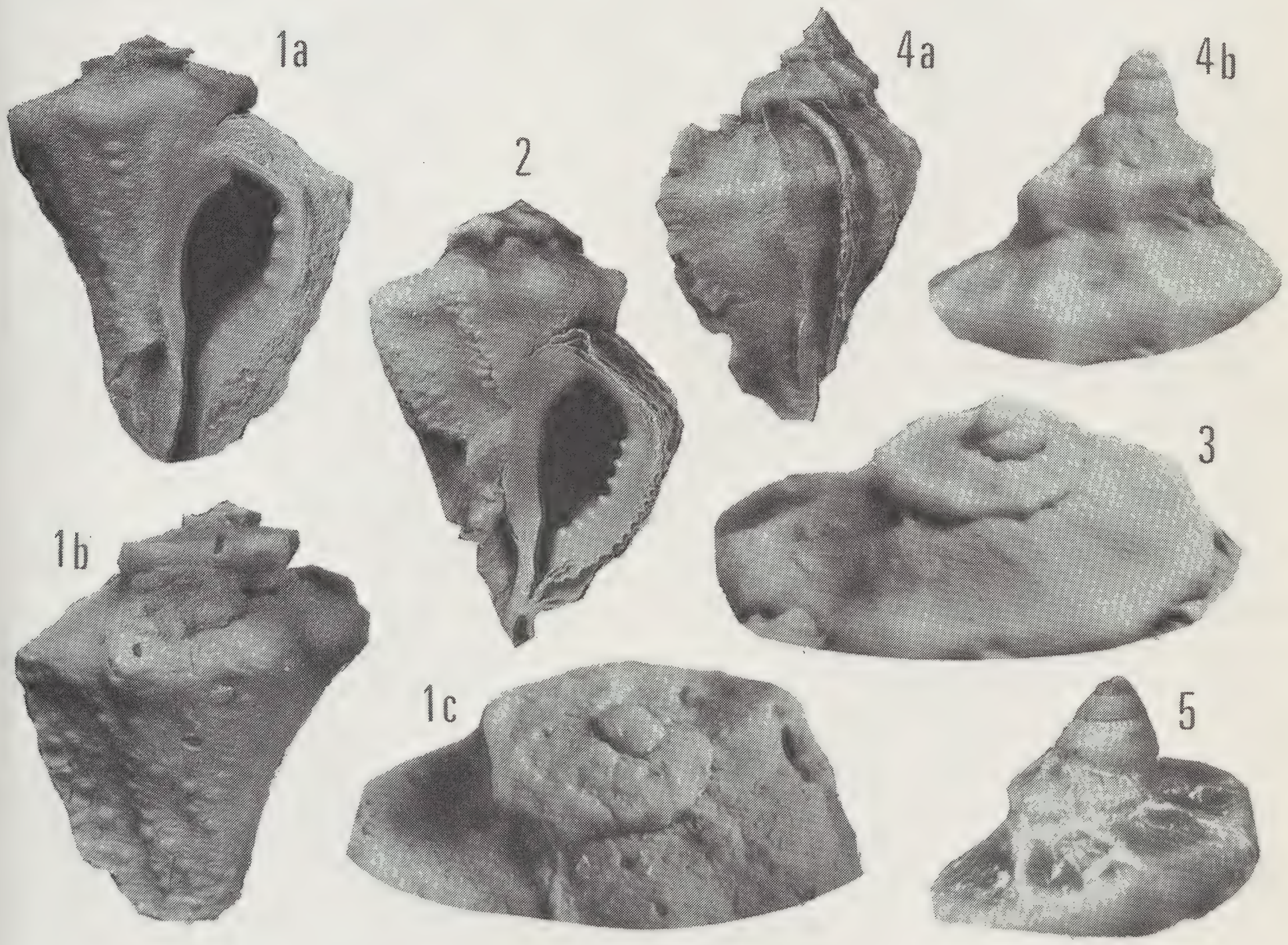
The first western Atlantic species described was *V. linguabison* (Vokes, 1967, p. 91) and since the initial discovery of the type lot only one other specimen has appeared in Florida. This came from a site (TU 1177) some 30 miles to the east-northeast of the type locality. But a number of specimens have been taken from the time-equivalent Agueguexquite Formation of southern Veracruz, Mexico (TU 638, 1046). From these a better idea of the species can be ascertained and the nature of the protoconch can be determined. A juvenile shell with a well preserved protoconch is figured here (text figures 4a, 4b) from the Mexican material. Not surprisingly *V. linguabison* proves to have a protoconch very much like that of the Recent *V. salebrosa,* its presumed descendant, with three and one-half conical whorls that rise above the apex of the shell (compare text figures 4b and 5).

The *Vitularia* from Santo Domingo is of particular interest as it more nearly resembles the Recent Indo-Pacific *V. miliaris* (Gmelin, 1791)*, than it does any of the New World forms. The new species has a protoconch like that of *V. miliaris,* consisting of one and one-half almost submerged whorls, barely visible above the top of the shell (compare text figures 1c and 3). The pustulose surface that is characteristic of the

*Radwin and D'Attilio (1976, p. 173) have placed all of the Indo-Pacific species of *Vitularia* in synonymy with *V. miliaris.* Considering the great variability seen in this group they are probably correct, with the possible exception of *V. crenifer* Montrouzier, 1861. The original illustration of this species shows a marked anal tooth, much like our Dominican shell, and if so, it is probably a valid form. The writer has never seen such a specimen from the Indo-Pacific area.

Old World *V. linguabovis* and *V. miliaris,* but almost lacking in the New World *V. linguabison* and *V. salebrosa,* is strongly developed in the Dominican shell. However, it has the strong anal tooth of the New World forms, not seen in *V. miliaris.* This is probably a primitive structure as *V. linguabovis* has the strongest anal tooth of all the species.

At the time of the description of *V. linguabison* the writer expressed doubts over the placement of the genus *Vitularia* in the Muricidae, suggesting perhaps it was more closely related to the Purpuridae (now Thaididae, ICZN Opinion 886, 1969). Radwin and D'Attilio (1976, p. 173, fig. 113) have recently given an illustration of the radula of *V. miliaris* and on the basis of similarity to other radulae have assigned *Vitularia* to the subfamily Muricopsinae. This is a difficult assignment to accept. Conchologically there is little in common between *Vitularia* and the typically fimbriate shells of the Muricopsinae, which includes such genera as *Murexiella, Muricopsis, Murexsul,* and *Favartia.* The operculum of *Vitularia* is of the purpuroid type rather than the muricoid one seen in the Muricopsinae. Thus, the implication is that perhaps we are seeing convergence in the radulae. Certainly any organ that is as likely to be affected by external factors, in this case feeding habit, as is the radula, seems an untrustworthy indicator of close relationship. (Compare, for example, the molars of the pig and man, both omnivores, which are strikingly similar; yet no one puts the two in the



Text figure 1, *Vitularia dominicana* E. H. Vokes, n. sp.; USNM 247902 (holotype). Figure 2, *V. miliaris* (Gmelin); Natal Museum H 218. Figure 3, *V. miliaris* (Gmelin); Natal Museum H 220. Figure 4, *V. linguabison* Vokes; USNM 247903. Figure 5, *V. salebrosa* (King and Broderip); USNM 770607. (Figures 1a, 1b, 2, and 4a, X 1½; figures 1c, 3, 4b, and 5, X 10.)

same family because of it.) There are many groups in the Thaididae that have a radula much akin to the Muricinae, especially *Morulina* (see Arakawa, 1965, pl. 14, figs. 7-14), but conchologically no one would put them anywhere except in the Thaididae. Therefore, it seems probable in this case that the radula is a false clue to the placement of the group and this writer still is of the opinion that the genus *Vitularia* is more likely a member of the Thaididae than of the Muricidae. Conchologically the only other group to which *Vitularia* may be related is the genus *Crassilabrum* Jousseaume, 1880, which Radwin and D'Attilio presumably place in the Thaididae (it is not treated in their work). *Crassilabrum, Thais,* and *Purpura* all have a strongly recurved median cusp on the rachidian tooth, not greatly different from *Vitularia.*

Genus VITULARIA Swainson, 1840

Type species: Vitularia tuberculata Swainson, 1840, by monotypy *(V. tuberculata* Swainson = *Murex miliaris* Gmelin, 1791).

VITULARIA DOMINICANA
E. H. Vokes, n. sp.
Text figures 1a, 1b, 1c

Diagnosis: Four post-nuclear whorls, plus a protoconch of one and one-half smooth submerged whorls. Spire greatly flattened. No surface ornamentation visible except seven or eight swollen knobs, which appear around the shoulder. No varices except at the aperture, where a fimbriate surface is developed between the outer surface of the shell and the inner side of the aperture. Surface of the body whorl covered with a pustulose surface, randomly arranged. Aperture ovate, slightly patulate; inner lip smooth, except for a moderately strong anal tooth, well within the posterior fold of the aperture. Inside of outer lip bearing seven large denticles. Anterior canal short, straight, with a broad siphonal fasciole.

Dimensions of holotype: height 28.2 mm, diameter 23.5 mm.

Holotype: USNM 247902.

Type locality: TU 1210, Rio Gurabo, east bank, first bluff below the bridge on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8544 and Maury's Zone B – her Pl. 3, fig. B, is probably this locality).

Discussion: At the time of the description of *V. linguabison* the age of the Pinecrest Beds was thought to be upper Miocene. Since then work on the planktonic foraminifers and nannofossils by Akers (1972, 1974) has demonstrated that the Pinecrest and the Agueguexquite formations are both Zone N 20, middle Pliocene, in age. The age of the Gurabo Formation has been considered to be middle Miocene, but Seiglie and Cucurullo (1971) have dated the Mao Adentro Limestone and the Mao Clay of Santo Domingo as Zones N 18 and N 19 (lower Pliocene), respectively. These two formations immediately overly the Gurabo Formation, in an unbroken sequence (although Seiglie and Cucurullo suggest a time gap between the two upper members), and it seems evident that the Gurabo is gradational into the Mao Adentro. According to Dr. Akers (personal communication) the age of the beds at TU 1210 is between Zones 17 and 19, unfortunately the necessary index fossils are lacking for a more precise determination. By process of elimination, Zone N 17 is indicated, or a late Miocene age.

Figured specimens: Fig. 1, *Vitularia dominicana* n. sp.; USNM 247902 (holotype). Fig. 2, *V. miliaris* (Gmelin); Natal Museum H 218; height 29.0 mm, diameter 21.6 mm; Conducia Bay, Mozambique. Fig. 3, *V. miliaris* (Gmelin); Natal Museum H 220; height 16.5 mm, diameter 14.6 mm (protoconch only figured); Memba Bay, Mozambique. Fig. 4, *V. linguabison* Vokes; USNM 247903; height 27.1 mm, diameter 17.3 mm; locality TU 1046. Fig. 5, *V. salebrosa* (King and Broderip); USNM 770607; height 6.4 mm, diameter 3.2 mm (protoconch only figured); locality TU R-250, Salina Cruz, Oaxaca, Mexico.

LOCALITY DATA

The following are Tulane University fossil locality numbers.

638. Agueguexquite Fm., roadcut and quarry on Mexico Highway 180, 14 miles (22.4 km) east of junction with side road into Coatzacoalcos, Veracruz, Mexico.

1046. Agueguexquite Fm., road cuts both sides Mexico Highway 180, 7.5 miles (12.1 km) east of junction with side road into Coatzacoalcos, Veracruz, Mexico (= locality of Perrilliat Montoya, 1960, Paleont. Mex., no. 8).

1177. Pinecrest Beds, "Mule Pen Quarry," north side of Florida Highway 846, 9.1 miles east of U.S. Highway 41 at Naples Park (SE ¼ Sec. 24, T48S, R26E) Collier Co., Florida.

1210. Gurabo Fm., Rio Gurabo, east bank, first bluff below the bridge on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8544; Maury's Zone B).

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November 16, 1977

NOTES ON THE FAUNA OF THE CHIPOLA FORMATION–XXII ON THE OCCURRENCE OF *DOLICHOLATIRUS* (MOLLUSCA:GASTROPODA)

EMILY H. VOKES
TULANE UNIVERSITY

The small genus-group for which the name *Dolicholatirus* is now employed has a lengthy geologic history, dating back to the late Cretaceous Owl Creek Formation of Mississippi. Here we see a curious species, named *Dolicholatirus torquatus* by Sohl (1964, p. 209, pl. 26, figs, 9, 10, 16, 17), that is to all indications a good case of ontogony *anticipating* phylogeny. The juvenile paratype *(ibid.,* figs. 9, 10) is apparently a good *Dolicholatirus,* with two faint columellar plications. The columellar lip, if it was ever present, has been broken away, leaving behind a *Fasciolaria*-like aperture, but the overall shell shape is identical to the modern members of *Dolicholatirus.* However, the adult holotype *(ibid.,* figs. 16, 17) has no visible plications as far into the aperture as it is possible to see without breaking away the shell and has an expanded body whorl that externally looks exactly like *Fasciolaria (Triplofusus).* This subgenus (type species: *Fasciolaria gigantea* Kiener) has three small plications at the anterior end of the columella, which is bent. The adult *D. torquatus* has a straight columella more like *Dolicholatirus.* Perhaps it is the ancestor to both lines.

Certainly by the Eocene the modern genus-group is well established. In the United States we see from the middle Eocene: *"Latirus" singleyi* Harris, 1895, and *"L." obtusus* Johnson, 1899; from the upper Eocene, *"L." leaensis* Harris, 1897; and from the Oligocene, *"Turbinella" perexilis* Conrad, 1847. In the Paleogene of Europe there are numerous species, including *"Fusus"*

funiculosus Lamarck, 1803, from the Eocene of the Paris Basin, and *"Fusus" cognatus* Beyrich, 1856, from the Oligocene of northern Germany.

After the Oligocene the line becomes much rarer, although world-wide in distribution. In the New World it is represented by a single species, *"Latirus" exilis* Gabb, 1873, from the Miocene beds of Santo Domingo. In the Old World we also see a single species from the middle Miocene of Italy, *"Fusus" bronni* Michelotti, 1847, type of the genus, and *"Fusus" aciformis* Tate, 1888, described from Australian beds originally thought to be Eocene but now known to be middle Miocene in age also.

In the United States the group has not been reported from the Oligocene up to the Recent where we see, among others, *"Fusilatirus" pauli* McGinty, 1955, a form very closely related to the Dominican Miocene form. Therefore, it was with some pleasure the genus was recognized in the fauna of the lower Miocene Chipola Formation of northwestern Florida. The line is extremely conservative, there being little change from the Eocene to the Recent species, but it was rather unexpected to find that the Chipola form is the same as that described by Gabb from Santo Domingo.

The shell of this genus is easily recognized by its long, perfectly straight, non-umbilicate anterior canal, resembling that of *Fusinus* s.s., and its two columellar plications, reminescent of *Latirus*. However, as shown by McGinty (1955, p. 79, text fig. A), the radula is unlike either of those genera. Although *Dolicholatirus* has frequently been assigned as a subgenus of *Latirus,* the differences seem such that the resemblances are probably coincidental.

Bellardi (1884, p. 38) was the first person to realize that the group of extremely elongated (*dolichos* – Greek, an elongated bean; the kidney bean) shells, bearing only two labial plications, represented a genus or subgenus separate from the similar appearing *Latirus (lathyros* – Greek, a bean; *Lathyrus* is the modern name of the sweet-pea). He included two species: *Latirus (Dolicholatirus) apenninicus* Bellardi and one which he cited as *"Turbinella" bronni* Michelotti. Of the latter he stated that Michelotti had published a "buonissima" figure (1847, pl. 10, fig. 15), however, there was no accompanying description. This is correct, Michelotti only listed the name in a table (1847, p. 398) with a footnote to the effect that this new species had been discovered too late to be included in the text. What is not correct is that Michelotti did not call it *Turbinella* but *Fusus.* This error was repeated by Cossmann (1901, p. 23) when he selected this species as type of the genus, which he considered as closer to *"Fusus"* (i.e., *Fusinus*), placing it in the "Fusinae," than to *"Lathyrus,"* which he placed in the Fasciolariinae. In terms of radular type the group is apparently not related to either of these, the radula being totally different. On radular bases alone it would seem closer to the Vasidae than anything in the Fasciolariidae. The geologic history of the line, wherein the morphotype has existed virtually without change since the Eocene, suggests that it is a completely distinct group and probably should have its own family.

Genus DOLICHOLATIRUS Bellardi, 1884

Dolicholatirus Bellardi, 1884, Moll. Terr. Terz. Piemonte e Liguria, pt. 4, p. 38 (as a "sezione," *i.e.,* subgenus of *Latirus* Montfort).
Type species, by subsequent designation, Cossmann, 1901: *"Turbinella" bronni* Michelotti [= *Fusus bronni* Michelotti, 1847].

Latirofusus COSSMANN, 1889, Cat. Illus. Coquilles Fossiles Eocene Paris, pt. 4, p. 179.
Type species, by original designation: *Fusus funiculosus* Lamarck.

Dolicholathyrus (emendation) COSSMANN, 1901, Essais Paléoconch. Comp., pt. 4, p. 22.

Fusilatirus MCGINTY, 1955, Acad. Nat. Sci. Phila., Proc., v. 107, p. 79.
Type species, by original designation: *Fusilatirus pauli* McGinty.

DOLICHOLATIRUS EXILIS (Gabb)

Text figures 1, 2

Latirus exilis GABB, 1873, Amer. Phil. Soc., Trans., (N.S.) v. 15, p. 217.

Latirus exilis Gabb. MAURY, 1917, Bulls. Amer. Paleont. v. 5, no. 29, p. 83(247), pl. 14(40), fig. 4.

Latirofusus exilis (Gabb.) PILSBRY, 1921, Acad. Nat. Sci. Phila., Proc., v. 73, p. 346, pl. 25, fig. 1.

Diagnosis: "Small, elongate, slender, spire longer than the aperture and canal; whorls numerous, suture bordered by a rib; surface marked by a very few large longitudinal ribs, five or six to a volution. These are crossed by strong revolving lines, of which about three appear on the upper whorls. Mouth small, oval, extended into a long slender, slightly curved canal; inner lip encrusted, the plate extending so as to make a raised sharp border to the mouth; internally marked by two strong transverse folds. Length 1.5 inch." (Gabb, 1873)

Dimensions of holotype: height 31.6 mm, diameter 9.5 mm.

Holotype: ANSP 2948.

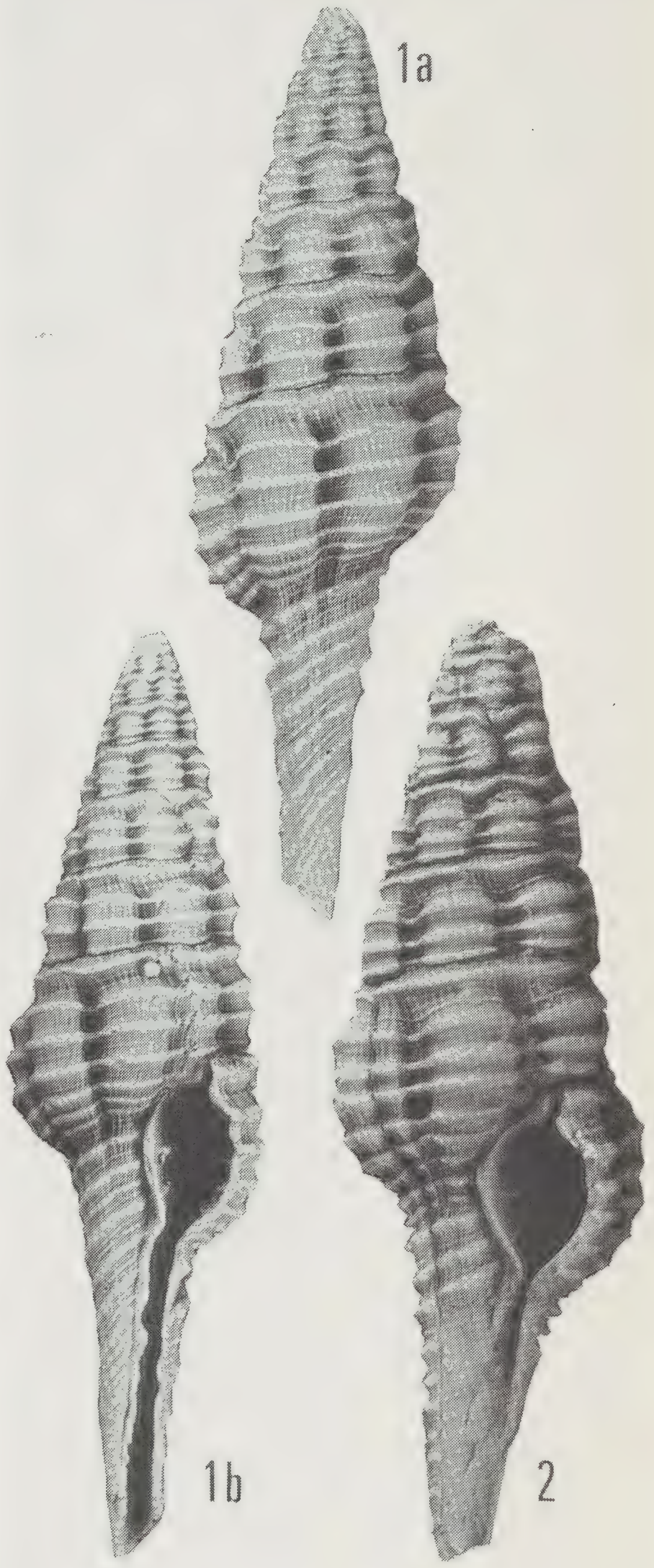
Type locality: Dominican Republic; Rio Gurabo near Los Quemados (= TU 1210), here designated.

Occurrence: Chipola Formation, lower Miocene; Florida. Cercado and Gurabo formations, (?) upper Miocene; Dominican Republic.

Figured specimens: Text figure 1, USNM 647712; height 20.3 mm, diameter 5.5 mm; TU 830. Text figure 2, USNM 248193; height 22.0 mm, diameter 7.3 mm; TU 1210. Other occurrences: TU locality numbers 1048, 1230.

Discussion: This small species is never common; in the Tulane Collections it is represented by four specimens, one from each of the four localities cited above. As was his usual practice, Gabb gave no data for his species, but both the Maury Collection (1917, p. 83) and ours made at the same spot, downstream from where the road crosses the Rio Gurabo west of Los Quemados (now a bridge, but a ford for Maury and Gabb), contain specimens and it is probable that this is also where Gabb made his collection. Therefore, TU 1210 is here designated as the type locality. This outcrop is in the Gurabo Formation, but the species also occurs in the Cercado Formation (TU 1230), which may be only a shallow-water facies of the deeper Gurabo Formation.

The Cercado and Gurabo formations were originally described as being of Aquitanian and Burdigalian ages, respectively. Subsequent work (of which there has been very little) suggests that the beds are younger. Seiglie and Cucurullo (1971) have dated the Mao Adentro Limestone and the Mao Clay as Zones N 18 and N 19 (lower Pliocene) and, as the Gurabo grades into the Mao Adento, it seems probable that the latter is approximately N 17, or uppermost Miocene. Neither the Gurabo nor the Cercado have



Text figure 1, *Dolicholatirus exilis* (Gabb), USNM 647712; locality TU 830, Chipola Formation. Text figure 2, *D. exilis* (Gabb), USNM 248193; locality TU 1210, Dominican Republic. (X 4)

yielded any definitive guide fossils, but according to W. H. Akers (personal communication) the beds at TU 1210 are between Zones N 17 and 19. The presence of a Dominican species in the Chipola Formation offers little assistance in an age determination, for, as noted above, the *Dolicholatirus* shell form is so conservative that there is little change from the Eocene to the Recent forms, and individual species would be expected to be long-lived. The Recent *D. pauli,* is also very much like *D. exilis* and may prove to be the same species. While it is unusual to find a lower Miocene species still living, it is not unheard of – in the Chipola there are approximately a dozen mollusks that still are found in the Recent fauna.

ACKNOWLEDGEMENTS

The writer would like to express her appreciation to Robert C. Hoerle, West Palm Beach, Florida, who collected the specimen figured from the Chipola Formation; to Thomas R. Waller, U.S. National Museum, and Earl A. Shapiro, Philadelphia Academy of Natural Sciences, for the loan of type specimens; and, especially, Robert C. Bullock, Dept. of Zoology, University of Rhode Island, for his assistance with the genus *Dolicholatirus*.

LOCALITY DATA

The following are Tulane University fossil locality numbers.

830. Chipola Fm., Ten Mile Creek, at power line crossing about one mile west of Chipola River (SE ¼ Sec. 12, T1N, R10W), Calhoun Co., Florida.

1048. Chipola Fm., Farley Creek, south bank, about 0.6 mile east of bridge on Florida Highway 275 (NE ¼ Sec. 21, T1N, R9W), Calhoun Co., Florida.

1210. Gurabo Fm., Rio Gurabo, east bank, first bluff below the bridge on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8544; Maury's Zone B).

1230. Cercado Fm., east bank of the Rio Caña at Caimito, just above bridge on road from Los Quemados to Sabaneta, Dominican Republic (Maury's Zone H).

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CONTENTS

VOLUME 14

Number — Page

1. DISTRIBUTION OF PLANKTONIC FORAMINIFERA IN SURFACE SEDIMENTS OF THE GULF OF MEXICO
Scott W. Snyder 1

2. *CRIBROLENTICULINA*, A NEW GENUS OF THE FAMILY NODOSARIIDAE EHRENBERG, 1838 (FORAMINIFERIDA)
Drew Haman 81

COMMENTS ON THE GENERA *MONTFORTELLA* LOEBLICH AND TAPPAN, 1963, AND *HETEROCIBICIDES* McCULLOCH, 1977
Drew Haman 103

3. A REVIEW OF THE VOLUTID GENERA *LYRIA* AND *FALSILYRIA* (MOLLUSCA: GASTROPODA) IN THE TERTIARY OF THE WESTERN ATLANTIC
Shirley E. Hoerle and Emily H. Vokes 105

COMMENTS ON SUBFAMILIAL RELATIONSHIPS IN TWO AMPHI-AMERICAN MURICID GENERA – *ACANTHOTROPHON* AND *ATTILIOSA*
George E. Radwin and Anthony D'Attilio 131

4. A PLEISTOCENE OSTRACODE FAUNA FROM SOUTH FLORIDA
Mervin Kontrovitz 135

AN OLIGOCENE (ORELLAN) SIRENIAN FROM THE BUCATUNNA FORMATION OF ALABAMA
Kenneth Whetstone and Larry D. Martin 161

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SCOTT W. SNYDER
EAST CAROLINA UNIVERSITY
GREENVILLE, NORTH CAROLINA

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Tulane University
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EAST CAROLINA UNIVERSITY
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CONTENTS

Page

I. ABSTRACT 2
II. INTRODUCTION 2
III. ACKNOWLEDGMENTS 2
IV. SAMPLES 3
V. METHOD OF STUDY 4
VI. PREVIOUS WORK 4
VII. CLASSIFICATION SYSTEM AND DISTRIBUTIONAL PATTERNS OF TEMPERATURE, SALINITY AND SURFACE CURRENTS 6
VIII. AGE OF SEDIMENTS 8
IX. CONCLUSIONS 10
X. DISTRIBUTION OF SPECIES 15
XI. REFERENCES CITED 70

ILLUSTRATIONS

TABLE I. Hierarchy of resistance to solution 9
FIGURE 1. Index map (sample localities) 3
FIGURE 2. Optimum ecological conditions for modern planktonic foraminiferal species 5
FIGURE 3. Mean surface water temperature (°C) in the Gulf of Mexico 6
FIGURE 4. Mean water temperature at a depth of 100 meters in the Gulf of Mexico 7
FIGURE 5. Mean surface water salinity in the Gulf of Mexico 8
FIGURE 6. Gulf of Mexico surface water currents 9
FIGURE 7. Areal distribution of Pleistocene sediments and sediments indicating significant vertical mixing 11
FIGURE 8. Areal distribution of planktonic to benthonic ratio values 11
FIGURE 9. Relative abundance, computed as a percentage of the total planktonic foraminiferal assemblage, of the tropical faunal element 13
FIGURE 10. Relative abundance, computed as a percentage of the total assemblage minus cosmopolitan and poorly understood species, of the tropical faunal element 13
FIGURES 11-46. Areal distributions of individual planktonic foraminiferal species . . . . . beginning on 16
PLATES 1-22 . . . . . beginning on 37

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I. ABSTRACT

Distributional patterns of 40 individual species and subspecies of planktonic Foraminifera are plotted on the basis of relative abundance at each of 90 stations located throughout the Gulf of Mexico. All species are illustrated with scanning electron photomicrographs.

There is only a poor relationship between the areal distribution of most species and the distribution of temperature and salinity values in the overlying water mass. Only nine species exhibit moderate correlation to trends of temperature and salinity in near surface waters. This results from factors that obscure such relationships during the process of incorporation into the sediments. Important factors in the Gulf of Mexico include the effects of surface currents and the absolute abundance of the particular species in question. Differential resistance to solution and downslope displacement are of lesser importance.

The concept of using "ideal" or key species as paleoecological indicators is rejected because no single species fulfills all of the requirements: sensitivity to temperature and salinity changes, high resistance to solution, and great absolute abundance. Plotting ratios between species indicative of different ecological conditions only compounds the problem. Dealing with larger faunal elements, such as tropical vs. non-tropical species, produces the most accurate reflection of conditions in the overlying water mass.

The relative ages of sediments exposed on the floor of the Gulf of Mexico were determined through the use of commonly accepted planktonic foraminiferal criteria. Except for the extreme southwestern portions of the study area, micropaleontological interpretations agree closely with those from the seismic profiler studies used to compile the preliminary map of the Gulf.

II. INTRODUCTION

The sensitivity of living planktonic foraminiferal species to variations in ecologic factors is now generally recognized. Although widely distributed, species are limited in the extent of their areal occurrence by these variations. This principle has been applied, although in only a few instances, to analyzing distributional patterns within surface sediments of ocean basins. Such studies have dealt with areas of the Pacific, Indian, and Atlantic oceans, but no definitive work of this nature has been attempted in the Gulf of Mexico. This study is an effort to provide analysis of distributional patterns within surface sediments of this previously unstudied area.

Although it is well known that planktonic foraminiferal species in living populations exhibit limited areal distributions, the preciseness with which these distributions are reflected by patterns within surface sediments is not well understood. Kennett (1969) and Boltovskoy (1971) have discussed the problem and offer somewhat conflicting viewpoints. Although no analysis of the distribution of living planktonic Foraminifera has ever been conducted throughout the entire Gulf of Mexico, large volumes of data are available on the physical oceanography of the area. These data were supplied to this writer by the National Oceanographic Data Center. By comparing the distribution of values for various factors with distributional patterns of planktonic foraminiferal tests in surface sediments, a means of indirectly correlating the living assemblage with the underlying thanatocoenose is provided. The dependability and accuracy of ecologic interpretations based on such thanatocoenoses can also be evaluated.

In addition to using planktonic species in ecological investigations, this study incorporates their usefulness as stratigraphic indicators. The exposure of ancient sediments over areas of the Gulf floor is indicated by the presence of characteristic faunal assemblages. Relative age determinations made in this manner can be compared to those made by the seismic profiler studies used to construct the preliminary geologic map of the Gulf of Mexico (Wilhelm and Ewing, 1972).

III. ACKNOWLEDGMENTS

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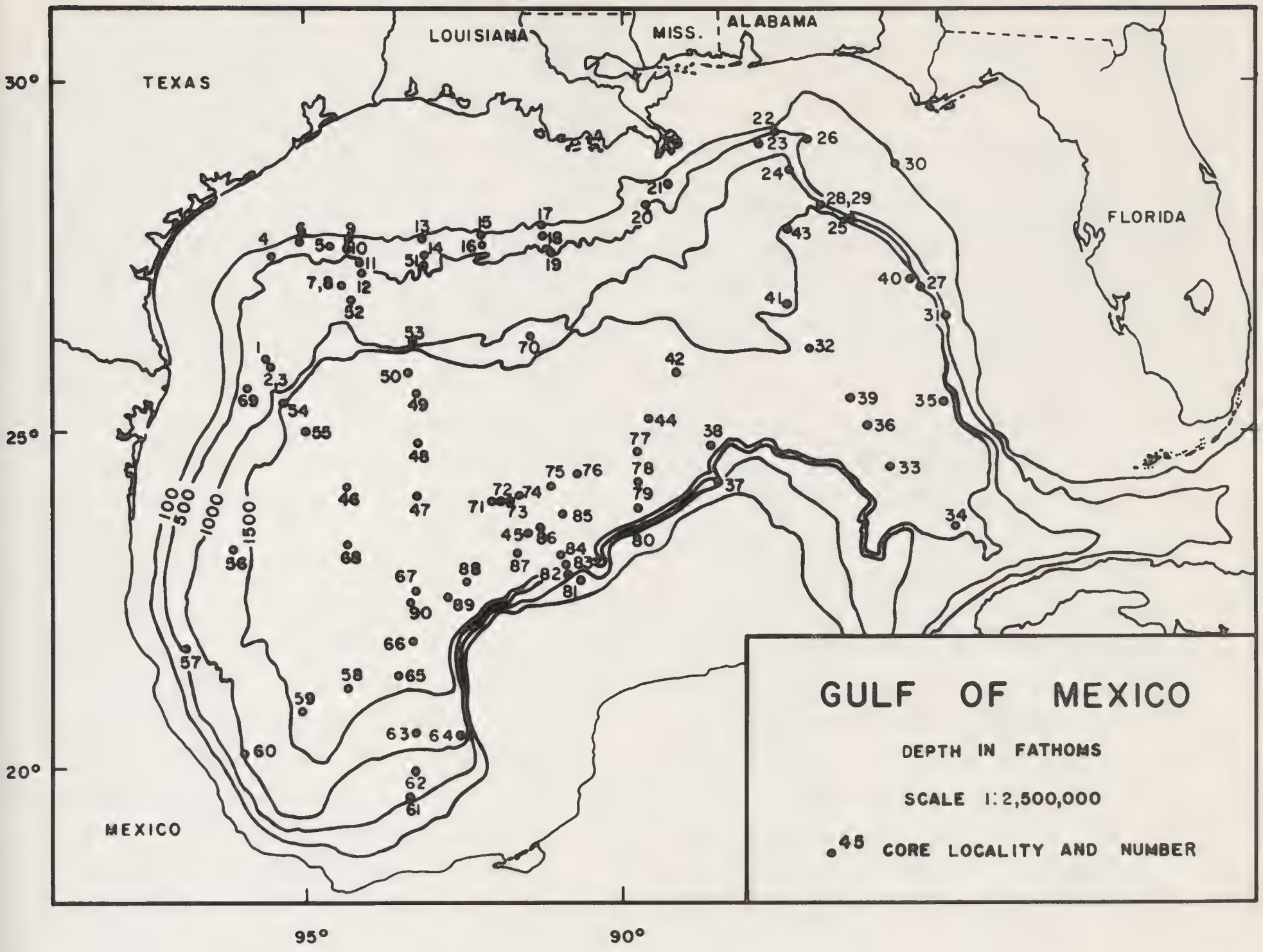

Figure 1. Index map (core locations and bathymetry).

instrumental in the completion of this project. Hubert C. Skinner has provided guidance and advice concerning numerous aspects of the project. W. H. Akers, of Chevron U S A, has assisted not only through discussions concerning taxonomy, but also by acting as an intermediary in securing the samples (from the Gulf of Mexico Slope Project) so kindly donated by Chevron. Herbert C. Eppert, Jr., of the U.S. Naval Oceanographic Office, supplied portions of all core materials recovered during Cruise 939014 of the USNS *Kane*. His time and effort in sampling those cores is greatly appreciated. The photographs presented here were taken with the Jelco scanning electron microscope (JSM-2) at Louisiana State University, Baton Rouge. The cooperation of Arthur Merkel, along with his instruction on the operation of the machine, made illustration with scanning electron photomicrographs possible. Part of the publication costs for this paper were provided by a grant from the Research Council of East Carolina University.

IV. SAMPLES

The samples utilized in this study were obtained from three independent sources. Materials recovered by the USNS *Kane* during Cruise 939014 were contributed by the U.S. Naval Oceanographic Office. Localities of these 39 samples are evenly dispersed throughout the Gulf of Mexico. Chevron Oil Company contributed materials from the continental slope area between eastern Texas and central Florida. These 31 samples were recovered through the joint effort of four major oil companies. Materials from a single traverse (64-A-9) of the RV *Alaminos*, operated by Texas A & M University, were available. These 20 samples are largely from the Sigsbee Deep but do include some material from the Campeche Slope. Coverage provided by combining samples from these three sources provides adequate control for

the Gulf of Mexico (fig. 1). All samples represent the uppermost sediment recovered during coring operations.

V. METHOD OF STUDY

Those materials obtained from Chevron Oil Company (now Chevron USA) and Texas A & M University had been washed prior to receipt. Those from the U.S. Naval Oceanographic Office were washed in the following manner. Several grams of sediment, in most cases all that was available, were boiled in a dilute solution of Quaternary "O" (several drops of Quaternary "O" per 50 ml water). This product is a very active detergent that aids in disaggregating the clay sized particles. Boiling for a period of approximately 45 minutes produced sufficient deflocculation. Samples were then washed on a U.S. Standard Sieve (No. 200) with sieve openings of 0.074 mm; immature planktonic foraminiferal specimens of lesser size generally cannot be differentiated into species categories. In order to avoid breakage, only a gentle stream of water was used in washing. The residue trapped on the sieve was, in most cases, a nearly pure concentrate of planktonic foraminiferal tests.

Washed sample material was reduced to a workable size with a microsplitter. Samples were not split beyond the point that produces aliquots equalling 1/32 the original volume, as beyond this point rare specimens may be eliminated. The material was then placed in a rectangular plastic picking dish marked with a grid of systematically arranged divisions. For samples that still contained great numbers of specimens, a random sampling was obtained through the unbiased, *a priori* selection of particular divisions in the picking tray from which specimens were to be counted. Care was taken to examine and count every specimen in the randomly designated divisions.

This process was continued until 300 to 400 specimens had been examined. Chang (1967, p. 500-502) has charted the relationship of maximal variability in percentage estimation, expressed as maximized standard deviation, with the studied population number. Working at a confidence interval of 95.4%, a studied population number of 300 specimens yields an estimate that is within 5% of the actual percentage of the species involved. Increasing the population number studied to 1000 reduces the margin of error only to plus or minus 3%. Thus, only a minimal improvement in accuracy would be attained by increasing the count threefold. Examining 300 to 400 specimens yields reasonably accurate and consistent results.

After 300 to 400 specimens had been identified and counted, larger volumes of the sample were examined. This allowed the presence of very rare forms, which might have been missed, to be recorded. Seldom did such searching yield a species that had not already been encountered. The number of specimens within each species was recorded and computed as a percentage of the total planktonic foraminiferal assemblage.

Benthonic species were also counted and identified at each station. Depth ranges, as presented by Phleger (1951), were recorded for all species identified. The primary purpose of this procedure was to determine the presence or absence of faunal elements from shallower areas. In this manner the extent of mixing due to downslope movement, and hence the dependability of percentages computed, can be evaluated.

VI. PREVIOUS WORK

During recent years the ecological optima and limitations of living planktonic foraminiferal species have been extensively studied. Numerous studies dealing with their areal distribution indicate that temperature is a primary controlling factor. Effects of temperature are manifested through the latitudinal segregation of species. Recognizing the broad pattern of segregation, the earliest studies concerning distributional patterns of planktonic Foraminifera categorized species as warm-tolerant, cold-tolerant, or cosmopolitan. Of early publications, those by Bradshaw (1959) and Bé (1959, 1960) rank among the most important.

Throughout the 1960's and into the present decade many workers have studied distributional patterns in various geographic areas. As detailed knowledge of physical

oceanography progressed so did the accuracy of estimates concerning ecological tolerances of planktonic foraminiferal species. Parameters other than temperature were measured and evaluated in terms of their controlling influence. Some of these factors, for example the concentration of inorganic nutrients, were found to influence total numbers of individuals, but temperature and salinity were established as the major limiting factors in the areal distribution of most species. Rather than describing species as merely warm-tolerant or cold-tolerant, precise optima were recorded for temperature (°C) and salinity (‰). Although estimates vary slightly from worker to worker, published data for most species are generally in close agreement (fig. 2). Among workers making contributions during this period, Bé and Cifelli, both publishing with various coworkers, and Boltovskoy have been the most active.

SPECIES	OPTIMUM TEMPERATURE RANGE (°C)	OPTIMUM SALINITY RANGE (‰)	OPTIMUM DEPTH RANGE (meters)	MAJOR FAUNAL GROUP	SOURCE
Globigerina					
bulloides	10-14	34-36	0-250	CT	1-6, 8-14
digitata	?	?	0-300	TR	2, 10
pachyderma	11-15	34.5-35	0-300	SP	1,2,4,6,8,10-14
quinqueloba	12-15	34.5-35	0-250	T	1,2,4,6,8-12,14
rubescens	?	?	0-250	ST	5,6,8-11
Globigerinella					
siphonifera	>20	>36	0-250	ST	1-6,8-11,13,14
Globigerinoides					
conglobatus	>21	>36	?	ST	1-4,6,8-11,13,14
elongatus	>20	>35.5	0-50	ST	4,9
quadrilobatus quadrilobatus	>22	>36	0-50	ST	4,5,7-9,13
quadrilobatus sacculifer	>23	>36	0-100	TR	1-11,13,14
ruber	>20	>35.5	0-50	ST	1-11,13,14
tenellus	?	?		?	5
Orbulina					
suturalis	?	?		ST	6,9
universa	>18	>36	0-300	ST	1-4,6,8-11,13,14
Hastigerina					
pelagica	>23	>36	0-300	ST	1-6,8-11,14
Sphaeroidinella					
dehiscens	16-20	?	200-300	TR	2,10,13
Candeina					
nitida	>20	>36	0-300	TR	1,2,4,6,8,10,11
Globigerinita					
glutinata	11-30	34-36	0-250	C	1-6,8-14
uvula	>10	34-35.5	>250	SP	8,12
Globoquadrina					
dutertrei	17-23	35.5-36+	0-150	WT	1-4,6-11,13,14
Pulleniatina					
obliquiloculata	19-25	>36	0-150	ST	1-4,6-8,10,11,13
Globorotalia					
crassiformis	16-26	>35.5	150-200	WT	1,3,4,6-10,13,14
hirsuta	18-21	>35	100-250	T	1-6,8-11,13,14
inflata	13-17	34-36.6	100-150	CT	1-6,8-14
menardii	17-25	>36	100-150	ST	1-11,13,14
scitula	15-17	?	200-300	T	2,5,6,8-10,12
truncatulinoides	15-22	35-37	100-225	ST	1-6,8-14
tumida	19-30	?	0-300	ST	2,8,10,11,13

Abbreviations: TR, tropical; ST, subtropical; WT, warm temperate; T, temperate; CT, cold temperate; SP, subpolar; C, cosmopolitan

Sources:
1. Bé, 1959
2. Bradshaw, 1959
3. Bé, 1960
4. Cifelli, 1965
5. Boltovskoy, 1966
6. Bé & Hamlin, 1967
7. Jones, 1967
8. Boltovskoy, 1969
9. Cifelli & Smith, 1970
10. Bé & Tolderlund, 1971
11. Bé, Vilks & Lott, 1971
12. Boltovskoy, 1971
13. Lynts, 1971
14. Tolderlund & Bé, 1971

Figure 2. Optimum ecological conditions for modern planktonic foraminiferal species.

Figure 3. Mean surface water temperature (°C) during each of four months of the year in the Gulf of Mexico. (after Greiner, 1970 from charts supplied by the National Oceanographic Data Center, 1966)

One logical correlative of such studies is the more detailed examination of selected species. Jones (1966, 1968) conducted such studies of populations in the Caribbean Sea. He has demonstrated that some species regarded as reliable indicators of major water masses are also excellent indicators of minor changes in environmental conditions. Small changes in any one of several ecologic factors may influence the areal distribution of such species. Figure 2 summarizes the present knowledge concerning optimum ecologic conditions for the species encountered in this study.

Another approach is the analysis of distributional patterns in surface sediments. Papers by Parker (1962), Ruddiman (1969), Kennett (1969), and Riess *et al.* (1971) present studies dealing with planktonic foraminiferal species in surface sediments of various geographic areas. Thus far, all that can be said is that latitudinal segregation, although not precisely correlative with that exhibited by living populations, does exist in surface sediment distributions.

VII. CLASSIFICATION SYSTEM AND DISTRIBUTIONAL PATTERNS OF TEMPERATURE, SALINITY, AND SURFACE CURRENTS

The organization of this paper follows the system of classification proposed by Parker (1967). Her classification, including only those genera encountered during this project, is outlined below.

Family GLOBIGERINIDAE

Globigerina
Globigerinella
Globigerinoides
Orbulina
Hastigerina
Pseudohastigerina
Sphaeroidinella

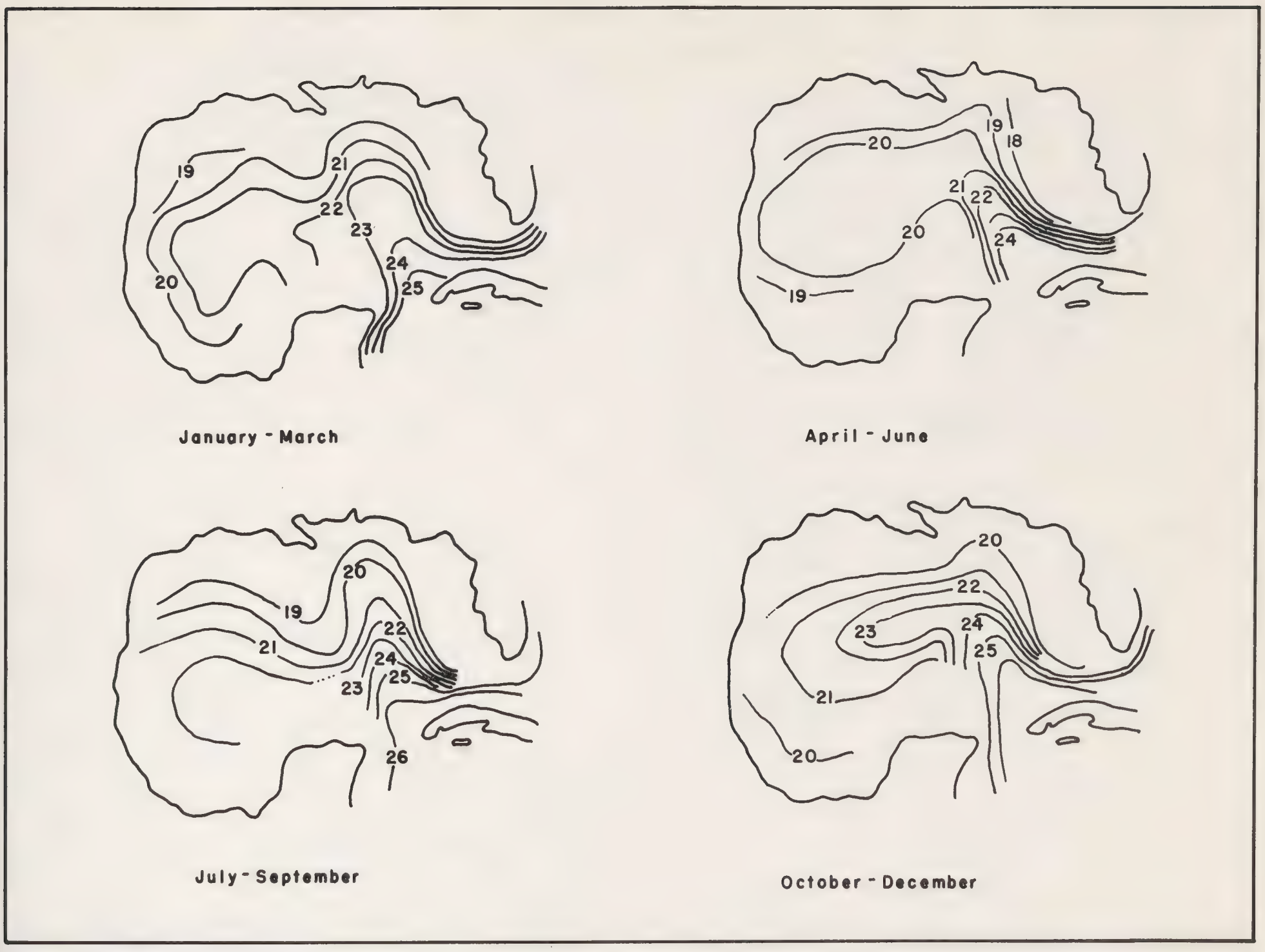

Figure 4. Mean water temperature (°C) for each of the four seasons of the year at a depth of approximately 100 meters in the Gulf of Mexico. (after Greiner, 1970 from charts supplied by the National Oceanographic Data Center, 1966)

Family CANDEINIDAE
Candeina
Globigerinita
Family CATAPSYDRACIDAE
Globoquadrina
Pulleniatina
Family GLOBOROTALIIDAE
Globorotalia

Parker's classification emphasizes the importance of true, elongate spines as a taxonomic character. Lipps (1966), utilizing microstructural characters, proposed a classification which agrees closely with that of Parker. Bé, Jongebloed, and McIntyre (1969) used point projection x-ray microscopy to examine internal morphology, variations in wall thickness from earliest to latest chambers, pore concentration, and pore diameter. Their classification is nearly identical to that of Parker. They differ only with respect to the placement of *Globigerinita.*

The basic organization of the above classifications differs from those of Bolli, Loeblich, and Tappan (1957) and Banner and Blow (1959). These workers emphasized the importance of mode of coiling, shape of chambers, position of apertures, number of chambers per whorl, presence or absence of keel, and ornamentation. Although arguments can be advanced for the use of each of these general systems of classification, that utilized by Parker has been selected for the present project.

The illustrations presented for each species represent an attempt to provide a nearly complete view of the range of variation within that species. They also summarize my interpretation of each species concept as it is presented by contemporary

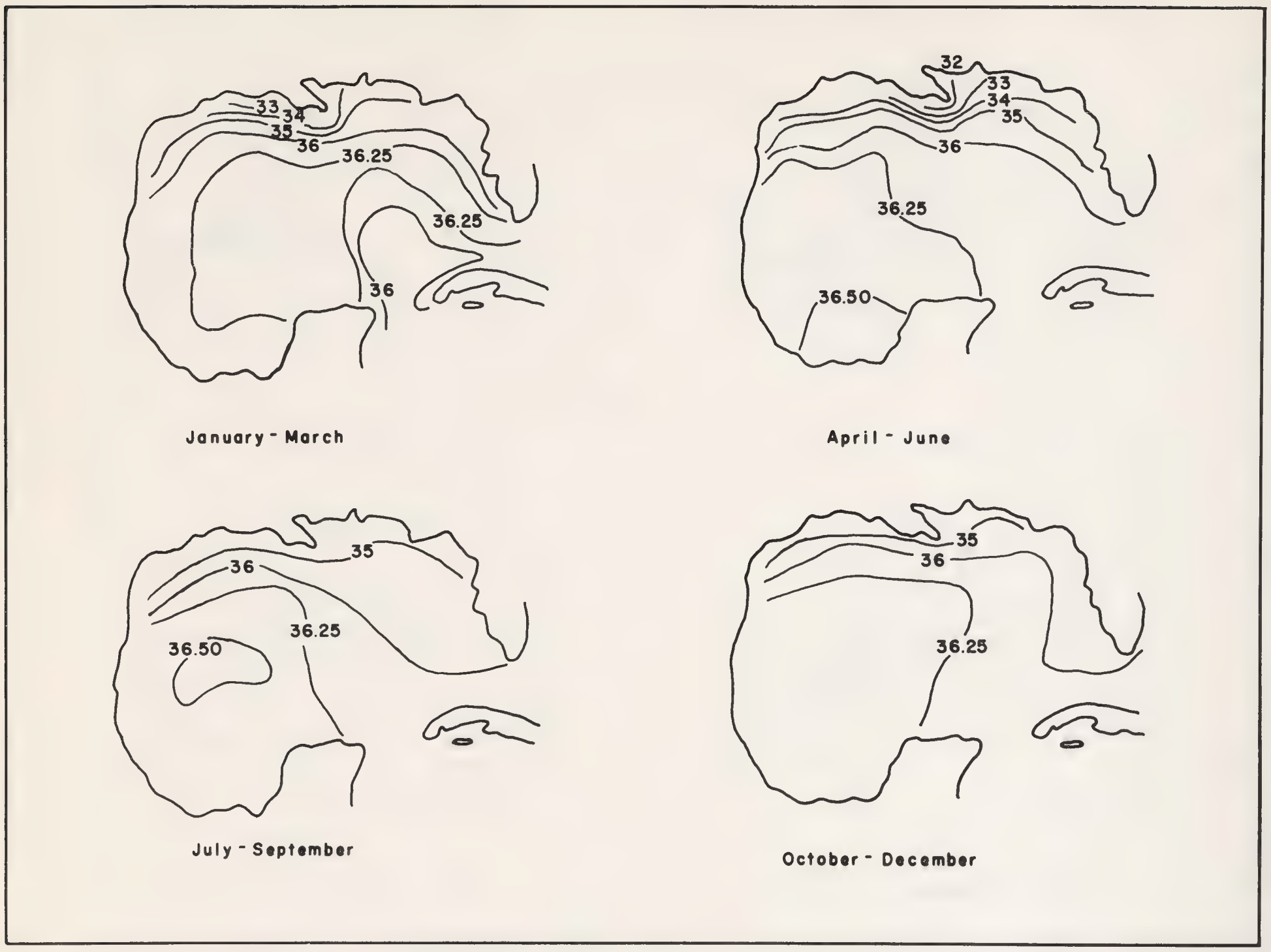

Figure 5. Mean surface water salinity (‰) during four seasons of the year for the Gulf of Mexico. (after Greiner, 1970 from charts supplied by the National Oceanographic Data Center, 1966)

workers. This approach serves to stress the populational aspect of these species. In addition, understanding each species concept as it is perceived by contemporary workers is necessary to utilize the ecological information that is provided almost exclusively by those same workers. The distributional pattern of each species is compared to charts on which are plotted the distribution of mean surface water temperature (fig. 3), mean water temperature at a depth of approximately 100 meters (fig. 4), and mean surface water salinity (fig. 5) during four seasons of the year in the Gulf of Mexico. The effects of surface water currents (fig. 6) are also considered.

Reference to Table I will supplement the discussions concerning the effects of solution. Those stations at which solution seriously distorts the estimates of relative abundance are relatively few. At stations 10 and 22 there is only moderate distortion but at stations 3, 5, 8, 20, and 32 the problem is serious. Samples from the latter five stations yield only those species most resistant to solution. Specimens are so few in number at these stations that percentage analyses are of little value.

VIII. AGE OF SEDIMENTS

The limited stratigraphic range of many planktonic foraminiferal species makes them useful for determining the relative age of sediments. Although distinguishing between late Pleistocene and early Holocene sediments is difficult, several criteria based upon planktonic Foraminifera are useful. Some species became extinct, or at least were excluded from the area of study, during the late Pleistocene. These include *Globorotalia flexuosa* and *Globorotalia inflata.* The presence of large numbers of either of these

Figure 6. Gulf of Mexico surface water currents. (from Greiner, 1970)

species suggests exposure of Pleistocene sediments. Several species are not encountered in sediments of the Gulf of Mexico until the Holocene. These include *Globorotalia ungulata* and the large, very tumescent forms of *Globorotalia tumida*. Other species, such as *Pulleniatina obliquiloculata finalis*, are encountered in the Holocene and uppermost Pleistocene. Large numbers of extinct and/or excluded species, combined with the absence of Holocene species, indicate the presence of pre-Holocene sediments. Small numbers of excluded species in samples where Holocene species are present in average concentrations are indicative of vertical mixing.

Differentiating between Pleistocene and Pliocene sediments is difficult because the definition of the Plio-Pleistocene boundary is still an unresolved issue. Without entering into a detailed evaluation of the various lines of evidence involved, the commonly used planktonic foraminiferal criteria are accepted for use in this study. These are the first abundant occurrence of *Globorotalia truncatulinoides* followed by the transition of populations of *Globorotalia menardii* to large and predominantly sinistral forms. Species considered characteristic of the late Pliocene, but which do not extend into the Pleistocene, include *Globoquadrina altispira, Globoquadrina venezuelana, Globorotalia multicamerata,* and *Globigerina nepenthes* (Lamb and Beard, 1972, p. 42).

Applications of these criteria to sediments examined during this study indicate that no sediments older than Pleistocene were encountered. All representatives of the *Globorotalia menardii* lineage are large and sinistrally coiled. *Globorotalia truncatulinoides* is present at all stations. Although the relative abundance is small at several localities, concentrations are generally between 3 and 10% of the planktonic fauna throughout the study area. Characteristic late Pliocene species were not identified from surface sediment samples anywhere within the study area. Finally, *Pulleniatina obliquiloculata finalis,* which does not appear until the late Pleistocene, is numerically important throughout the area.

Table I
Hierarchy of Resistance to Solution

(modified from Jenkins and Orr (1972) after Berger (1970)

Low resistance

1. *Globigerinoides ruber*
2. *Orbulina universa*
3. *Globigerinella siphonifera*
4. *Globigerina rubescens*
5. *Globigerinoides quadrilobatus sacculifer*
6. *Globigerinoides tenellus*
7. *Globigerinoides conglobatus*
8. *Globigerina bulloides*
9. *Globigerina quinqueloba*
10. *Globigerinita glutinata*
11. *Candeina nitida*
12. *Globorotalia hirsuta*
13. *Globorotalia truncatulinoides*
14. *Globorotalia inflata*
15. *Globorotalia menardii*
16. *Globoquadrina dutertrei*
17. *Globigerina pachyderma*
18. *Pulleniatina obliquiloculata*
19. *Globorotalia crassiformis*
20. *Sphaeroidinella dehiscens*
21. *Globorotalia tumida*

High resistance

Sediment samples that can be assigned confidently to the Pleistocene are limited to only eleven localities (fig. 7). The assemblages present at Stations 2, 13-16, 25-27, 40, 50 and 51 are interpreted as exposures of Pleistocene sediments. Those at Stations 22, 23, 28, 29, 30 and 31 indicate vertical mixing. Significant distortion of species percentage estimates probably does not occur at these latter stations.

The areal distribution of exposed Pleistocene sediments, as determined by using planktonic foraminiferal criteria, can be compared to the results of Wilhelm and Ewing (1972). Utilizing seismic profiler data, these authors have compiled a preliminary geologic map of the Gulf of Mexico. Except for the extreme southwestern portion of the Gulf, their findings, based solely upon geophysical data, are in close agreement with micropaleontological evidence. Abyssal portions of the Gulf are covered by Holocene sediments. The Mississippi cone, also covered by Holocene sediments, is flanked by continental slope areas to the west and east. Here, from southern Texas to eastern Louisiana, and again off the coast of eastern Mississippi and western Florida, Pleistocene sediments are exposed. Although not as continuous areally as is indicated by seismic profiler data, sediments here interpreted as Pleistocene occur only in these two general areas (fig. 7).

At this point, the similarity between the results from geophysical and paleontological analyses deteriorates. Surface sediments from continental slope areas adjacent to the Campeche Escarpment and the Western Florida Escarpment yield Holocene planktonic foraminiferal assemblages. However, based upon seismic profiler data, correlation with coastal formations indicates this area is covered by Miocene and Pliocene sediments. The same relationship exists over the much more gentle and geographically more extensive continental slope in Campeche Bay. Along steep escarpments the reason for this discrepancy may be related to downslope displacement of Quaternary sediments. The presence of small numbers of shallower water benthonic Foraminifera in abyssal sediments adjacent to steep slope areas supports this suggestion. Thicker deposits of the late Tertiary, as detected by seismic methods, may be overlain by a very thin veneer of Holocene sediments. This veneer, undetected because it is so thin, yields the assemblages described in this report. The mechanism for such transport of Quaternary materials is more difficult to visualize for the gentle slopes in Campeche Bay. Perhaps slow rates of deposition explain the presence of a thin veneer of Holocene sediments in this area.

IX. CONCLUSIONS

Distributional Patterns of Individual Species

Distributional patterns of the relative abundances for individual species (figs. 11-46) show varying degrees of correlation with the values of temperature and salinity in the overlying water mass. No single species has a pattern within the surface sediments that corresponds closely with the areal patterns displayed by either of these ecological parameters. The pattern of a number of species correlates moderately well with those of temperature values. These species include:

Globigerina bulloides
Globigerina digitata
Globigerina pachyderma
Globigerinella siphonifera
Globigerinoides quadrilobatus quadrilobatus
Globigerinoides quadrilobatus sacculifer
Globigerinoides ruber
Globorotalia tumida
Globorotalia ungulata

The remainder of the species present in surface sediments of the study area have distributions that show little or no correlation with those of temperature and salinity values. However, living specimens of many of these species are known to be highly sensitive to changes in those same parameters. During the process of incorporation into sediments, a number of factors evidently masks the record of this sensitivity.

One such disrupting factor is solution. As noted in Table 1, planktonic foraminiferal species exhibit different degrees of resistance to solution. As solution becomes progressive-

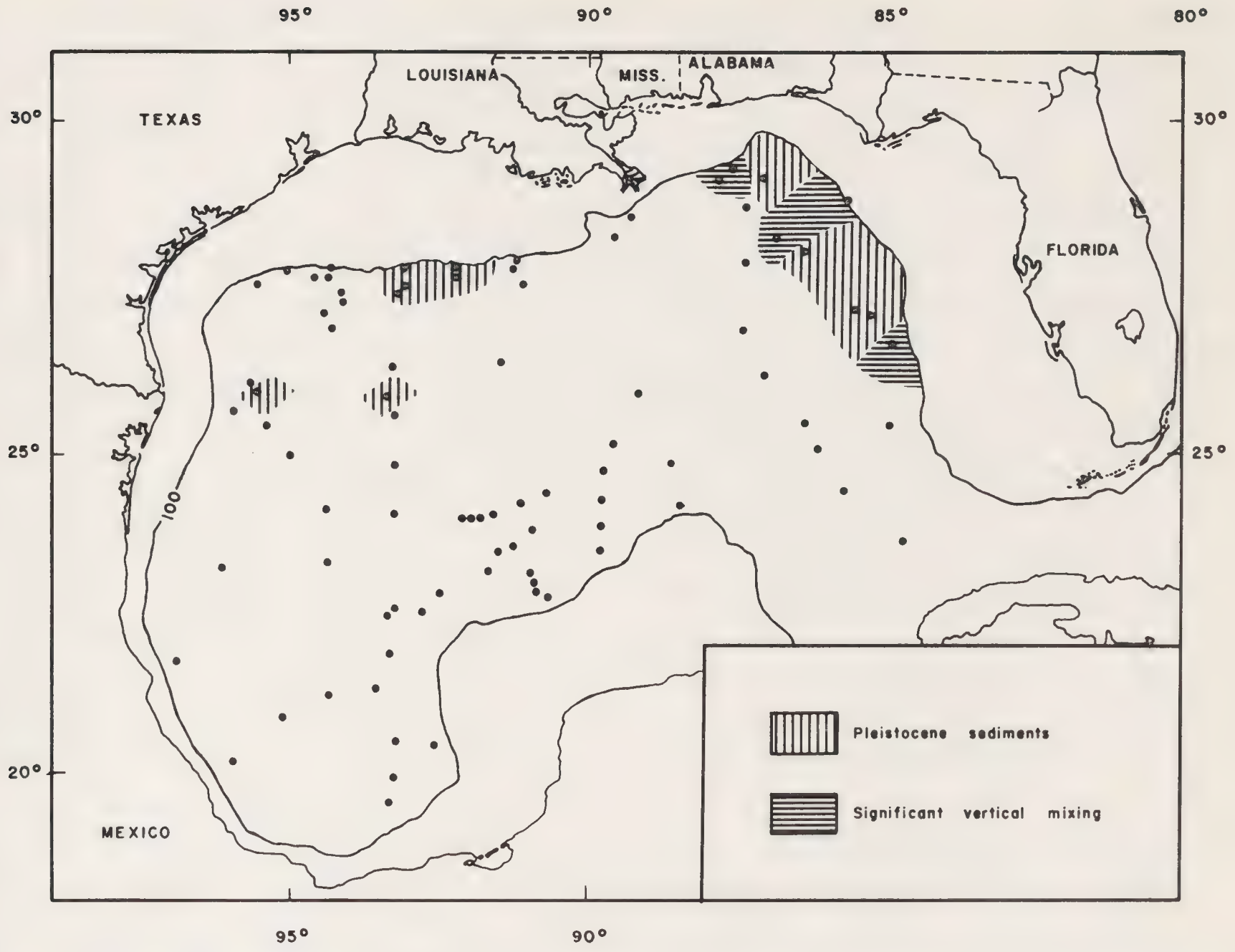

Figure 7. Areal distribution of Pleistocene sediments and sediments indicating significant vertical mixing.

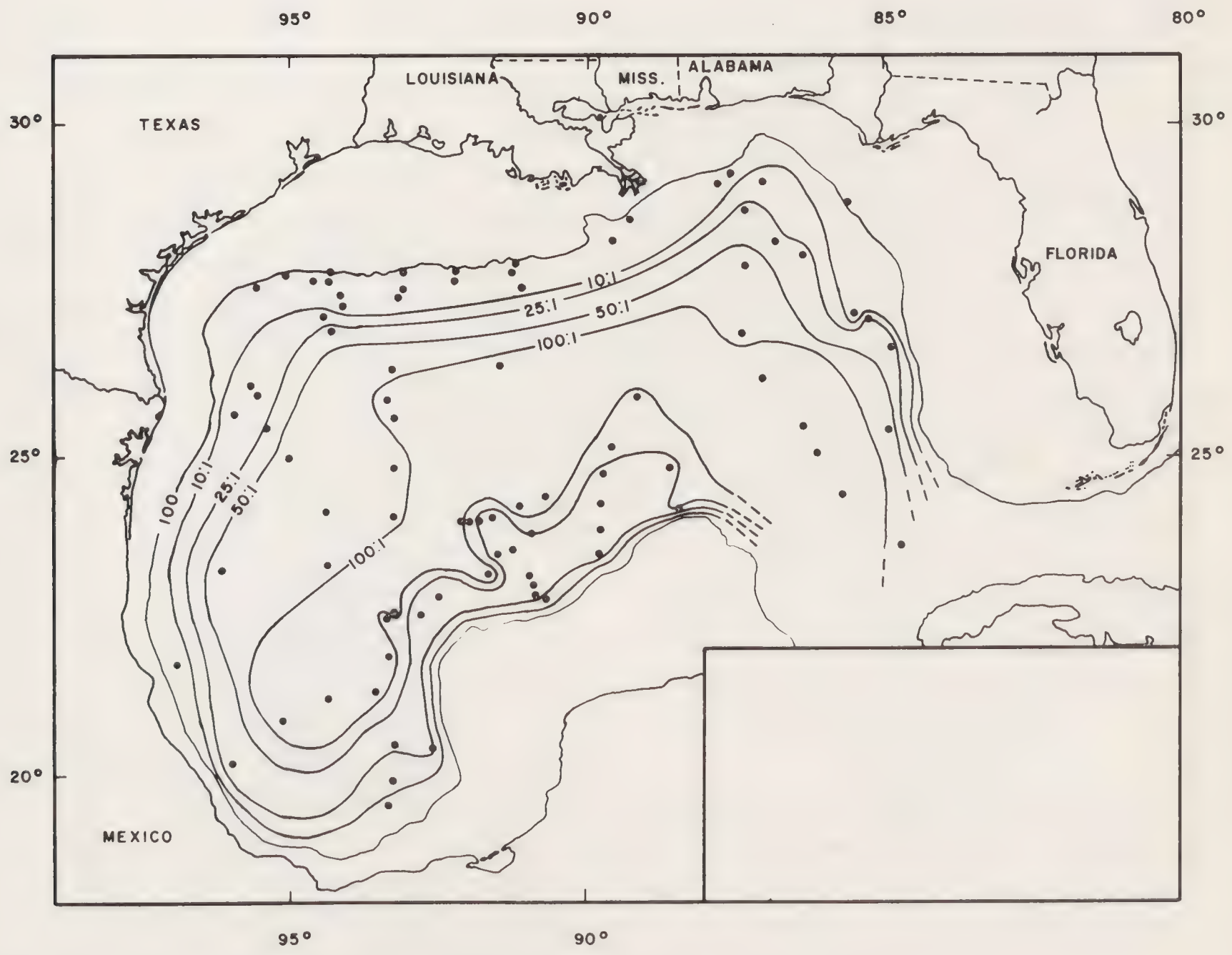

Figure 8. Areal distribution of planktonic to benthonic ratio values.

ly more extensive, there are concomitant changes in the aspect of the fauna. Relatively minor solution will result in the absence of thin-walled and fragile species (Jenkins and Orr, 1972, p. 1074). As with any attribute characterized by negative evidence, this stage of solution is often difficult to recognize. Intermediate solution, which eliminates immature forms and partially dissolves the tests of more resistant species, is much more easily recognized. Complete solution will, of course, result in the absence of all species. Solution is not a major modifying factor of distributions within surface sediments of the Gulf of Mexico. Evidence of intermediate solution is encountered at only seven stations (3, 5, 8, 10, 20, 22, and 32). Although difficult to assess, the error introduced by minor solution effects is probably negligible.

Surface currents may also be a disrupting factor. In many areas of the Gulf of Mexico these currents trend across changes in temperature and salinity values (compare figure 6 with figures 3, 4, and 5). Here their mixing effects may hinder recognition of the relationship between the distribution of a species and the ecological factor or factors operative in limiting that distribution. This is especially true when the tests of dead planktonic organisms are transported away from the area in which the organisms lived. Surface currents are important modifiers of planktonic foraminiferal distributions in surface sediments of the study area. Not only do they strongly influence the patterns of many individual species, but their effects are also evident in patterns involving larger faunal elements. Plots of tropical versus non-tropical elements (figs. 9 and 10) indicate a particularly strong influence in the western Gulf at approximately latitude 26°N. Here the convergence of two separate current systems (fig. 6) is the major influencing factor on planktonic foraminiferal distributions in surface sediments.

Downslope movement of sediments may alter the relative abundance computed for species in samples from deep water. Contamination by displaced faunal elements can be detected by the presence of benthonic foraminiferal species that live in shallower water. Significant numbers of shallow water forms would suggest serious error due to downslope movement. No such evidence exists in the samples from the Gulf of Mexico. Although minor amounts of displacement have been well documented, at no station does contamination seriously alter the values of relative abundances.

Finally, the absolute number of specimens representing a particular taxon may affect distributional patterns. Species represented by very few specimens may show marked percentage variations in response to minor fluctuations in the severity of disrupting factors. The patchy, discontinuous distributions of some species, most of which constitute less than 1% of the planktonic foraminiferal fauna, probably arise in just this manner.

The above discussion considers the major factors, which alter relationships, that might exist between species distributions and ecological parameters. Of course, living specimens of different species vary in sensitivity to changes in ecologic factors (fig. 2). Those species that are most sensitive to such changes would theoretically be the most useful for paleoecological interpretations. However, susceptibility to disruptive factors is also an important consideration.

The "ideal" species to utilize as a paleoecological indicator would possess the following characters: sensitivity to changes in ecological factors (salinity and temperature), high resistance to solution, and great absolute abundance. Unfortunately, no single species adequately fulfills all of these requirements. *Globigerinoides ruber* approaches this "ideal" condition as closely as any species present in the study area. A good warm water indicator, it is the most abundant species in the Gulf of Mexico. However, it is more susceptible to solution than any other planktonic species (table 1). *Globorotalia tumida,* another good warm water indicator that is also highly resistant to solution, exhibits only small absolute abundances. Some species, such as *Globigerinita glutinata,* are abundant and fairly resistant to solution but tolerate broad ranges of

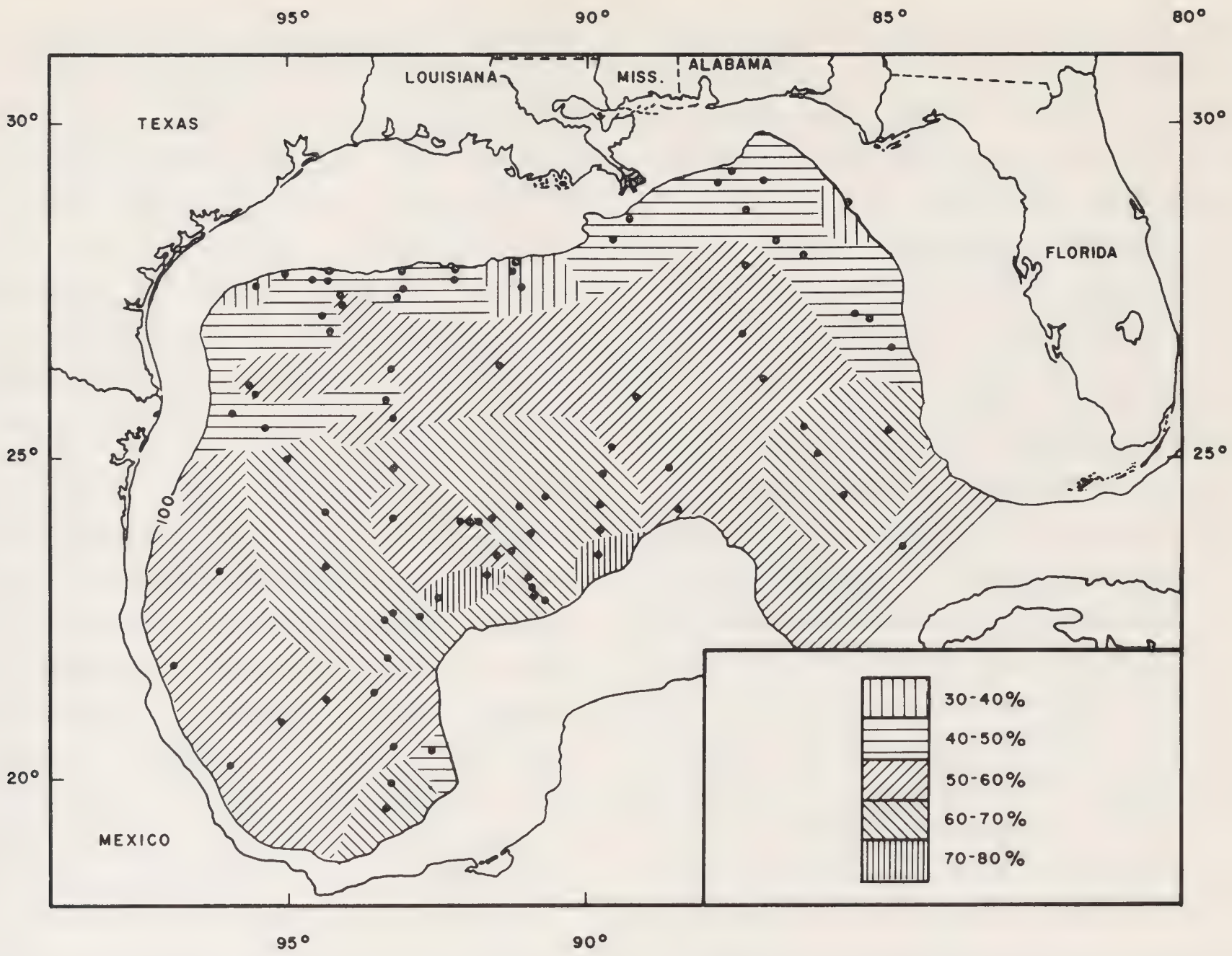

Figure 9. Relative abundance, computed as a percentage of the total planktonic foraminiferal assemblage, of the tropical faunal element.

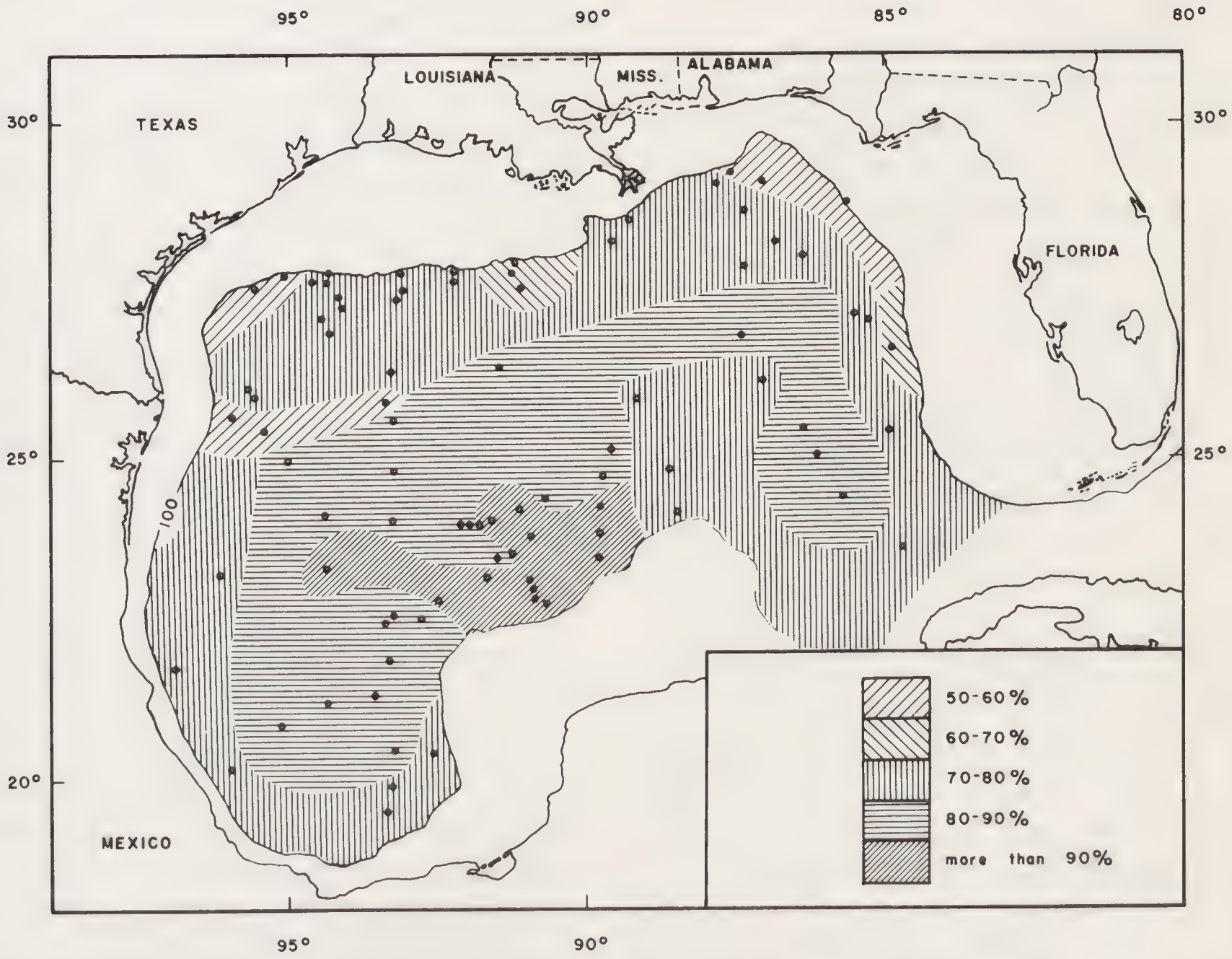

Figure 10. Relative abundance, computed as a percentage of the total assemblage minus cosmopolitan and poorly understood species, of the tropical faunal element.

temperature and salinity. In summary, there is no "ideal" species. Each one is susceptible, albeit in varying degrees, to disrupting factors that mask its relationship to measurable ecological parameters.

Although the refinement of knowledge concerning the optimum ecological conditions for living specimens is most interesting, the prospect of utilizing such detailed knowledge for interpreting thanatocoenoses is not favorable. Too many variables exist to attempt more than generalized estimates of past climatic conditions. In terms of broad latitudinal patterns, the thanatocoenoses of surface sediments of the Gulf of Mexico conform well with that which would be expected. That is, in terms of major faunal groups, these assemblages can be described as subtropical. Analysis of distributional patterns exhibited by individual species supports slightly more detailed interpretations. Generalized estimates of temperature and salinity maxima and minima, along with an appreciation for broad trends exhibited by values of these parameters, represent optimum attainable results.

Other Approaches

Several approaches, other than the relative abundances of individual species, have been utilized to interpret the paleoclimatic implications of thanatocoenoses. These include the planktonic number, the planktonic to benthonic ratio, ratios of various species to other selected species, and the species diversity index.

The planktonic number was not utilized during this investigation because samples from two of the three sources were washed through a sieve prior to receipt by the writer. Theoretically, this technique provides some basis for estimating the absolute abundance of planktonic Foraminifera. Unfortunately, values depend upon both the rate of sedimentation and primary productivity. Values cannot be correlated with ecological parameters unless detailed knowledge of sedimentation rates is available.

Another common procedure is plotting values of the ratio between two selected species. The species are selected because they are considered indicative of different ecological conditions, and because they approach the "ideal" indicator species condition. Because no individual species corresponds closely to this "ideal," establishing a ratio between two such species yields no increased benefits. Indeed, it may even increase the complexity of the situation. The two species used in computing such a ratio may not be reacting to the same factors. The resultant ratio may, therefore,be independent of the particular parameter or parameters being considered. In addition, the initially computed relative abundances are influenced by various disruptive factors. Errors inherent in these initial estimates will vary from species to species according to which disruptive processes are operative, the severity of these processes, and the susceptibility of individual species to them. The relationship of any such ratio to values of temperature and salinity becomes hopelessly obscured.

The ratio of planktonic to benthonic foraminiferal specimens is another commonly used measurement. Because it is strongly influenced by physiographic setting, the distribution of values of this ratio is closely related to regional bathymetry. This relationship would be disrupted by extensive downslope movement. Close correlation between the P/B ratio and bathymetry in the Gulf of Mexico (fig. 8) serves as substantive evidence that such displacement is of minor importance. Differential solution of foraminiferal tests might also seriously distort values of this ratio. Its close correlation with bathymetry lends support to other lines of evidence suggesting solution is a relatively minor modifier of foraminiferal assemblages.

Analysis of species diversity represents another approach to ecological studies. "The species diversity index is a measure of the relative concentration or variety of species within a biologic community" (Gibson, 1966, p. 117). There are a number of diversity indices, many of which do not follow parallel trends in the same developmental series. These indices incorporate more than a single component of diversity, usually variety and evenness in apportionment of individuals among species. The writer follows Tolderlund and Bé (1971) in using a modifi-

cation of the index proposed by Simpson in 1949. It is calculated as follows:

$$I = \frac{\sum^{x}_{i=1} n_i (n-1)}{N (N-1)}$$

where n equals the number of individuals in species n_1, $n_2, \ldots n_x$, and N equals the number of individuals in the sample (Tolderlund and Bé, 1971, p. 318). In order to avoid confusion, the value of this index is subtracted from unity so that the index increases as diversity increases. The value of this index was computed for each station. A plot of values throughout the study area revealed absolutely no relationship to the distribution of temperature and salinity values within the Gulf of Mexico. However, the values are similar to those of seasonal peaks for living planktonic Foraminifera in subtropical areas (Tolderlund and Bé, 1971, p. 318).

Limitations of Analyses Based on Thanatocoenoses

Throughout this discussion, reference has been made to the difficulties in deriving precise ecological interpretations from assemblages within surface sediments. In this context, 'precise' simply means accuracy comparable to present knowledge about the ecology of living representatives from various species. Distortion by disrupting factors, such as solution and surface currents, makes precise interpretations based on the distributions of individual species impossible. Various other commonly used approaches are affected by the same factors. In addition, some of these introduce unfounded assumptions, which produce even greater complexities.

Grouping assemblages into larger elements, such as tropical and non-tropical, decreases the precision of interpretations. It also negates much of the distortion inherent in dealing with more limited groups. As the number of components within the system increases, statistical limitations imposed upon that system decrease. Figure 9 displays the distribution of tropical species computed as a percentage of the total planktonic foraminiferal fauna. Relative abundances correlate well with the distribution of temperature values, especially those at a depth of 100 meters (fig. 4). Correlation with temperature values is improved when the tropical species are computed as a percentage of the total assemblage minus ubiquitous and poorly understood species (fig. 10). Such species are readily recognizable in Figure 2. These distributions reflect prominent trends in temperature values of the overlying, near-surface water mass. Utilizing knowledge about the optimum ecological conditions for those species that are good temperature indicators, generalized estimates of temperature maxima and minima are discernible. Salinity does not appear to be an important influencing factor. Analysis based upon major faunal elements, such as that described above, represents the ultimate accuracy attainable in interpretation of thanatocoenoses.

X. DISTRIBUTION OF SPECIES

Family GLOBIGERINIDAE Carpenter, Parker, and Jones, 1862

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA BULLOIDES d'Orbigny

Plate 1, figures 1-6

Globigerina bulloides D'ORBIGNY, 1826, Ann. Sci. Nat., (ser. 1), vol. 7, p. 277, nos. 17 and 76.

Globigerina bulloides is clearly distinguishable from other species, except for some specimens of *Globigerina falconensis;* however, the latter species tends to have slightly more elongate final chambers and a more constricted aperture with a more prominent lip. In surface sediments of the study area they are separable into distinct groups that are assigned species rank by this writer.

Globigerina bulloides constitutes 1 to 3% of planktonic foraminiferal assemblages in surface sediments over most of the Gulf of Mexico (fig. 11). Areas with relative abundances of less than 1% are located along the continental slope off Florida and in the south-central portion of the Gulf basin. Relative abundances ranging from 5 to 10% occur at several isolated stations. Percentages ranging from 3 to 5% are characteristic of the continental slope areas off the coast of

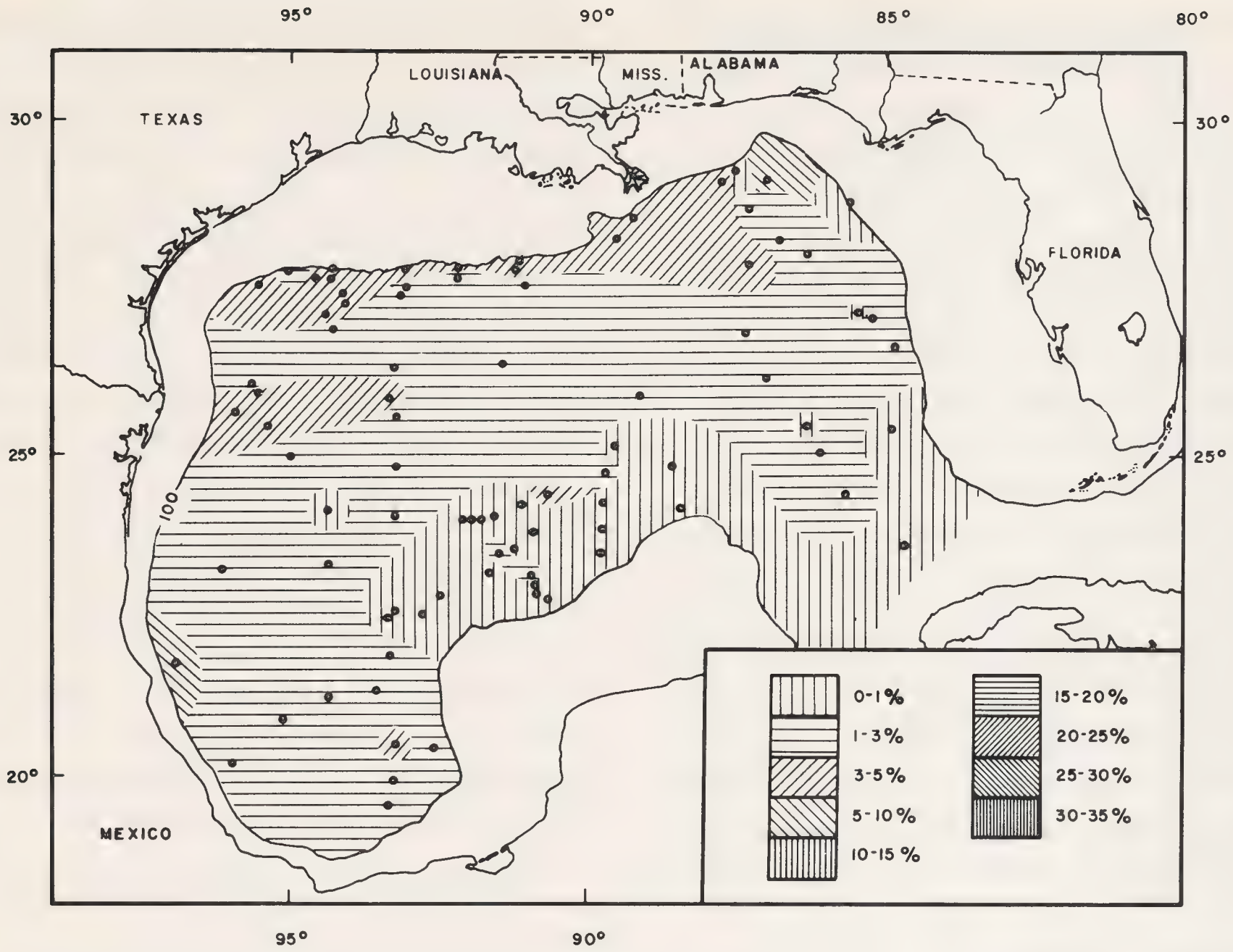

Figure 11. Relative abundance of *Globigerina bulloides.*

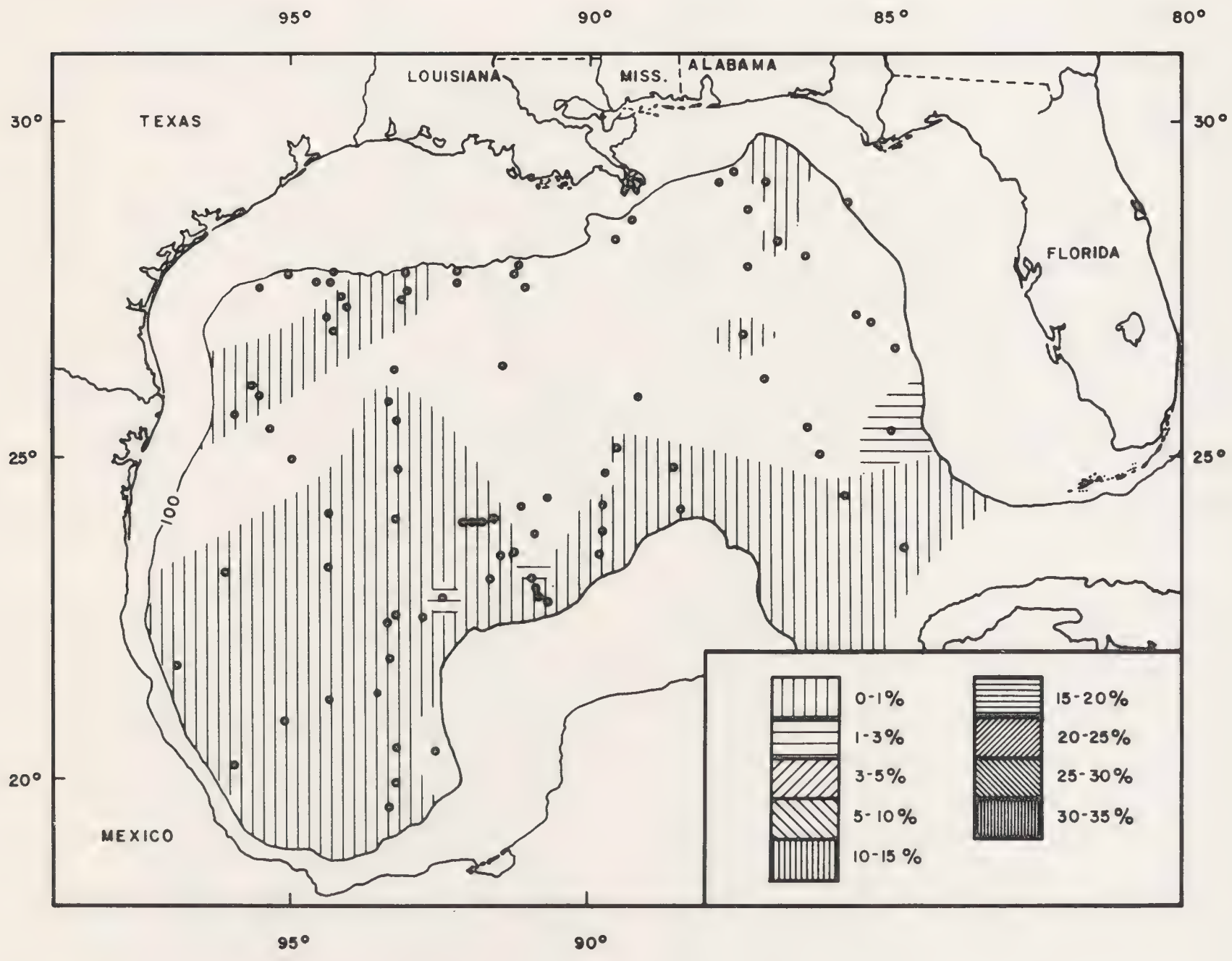

Figure 12. Relative abundance of *Globigerina calida.*

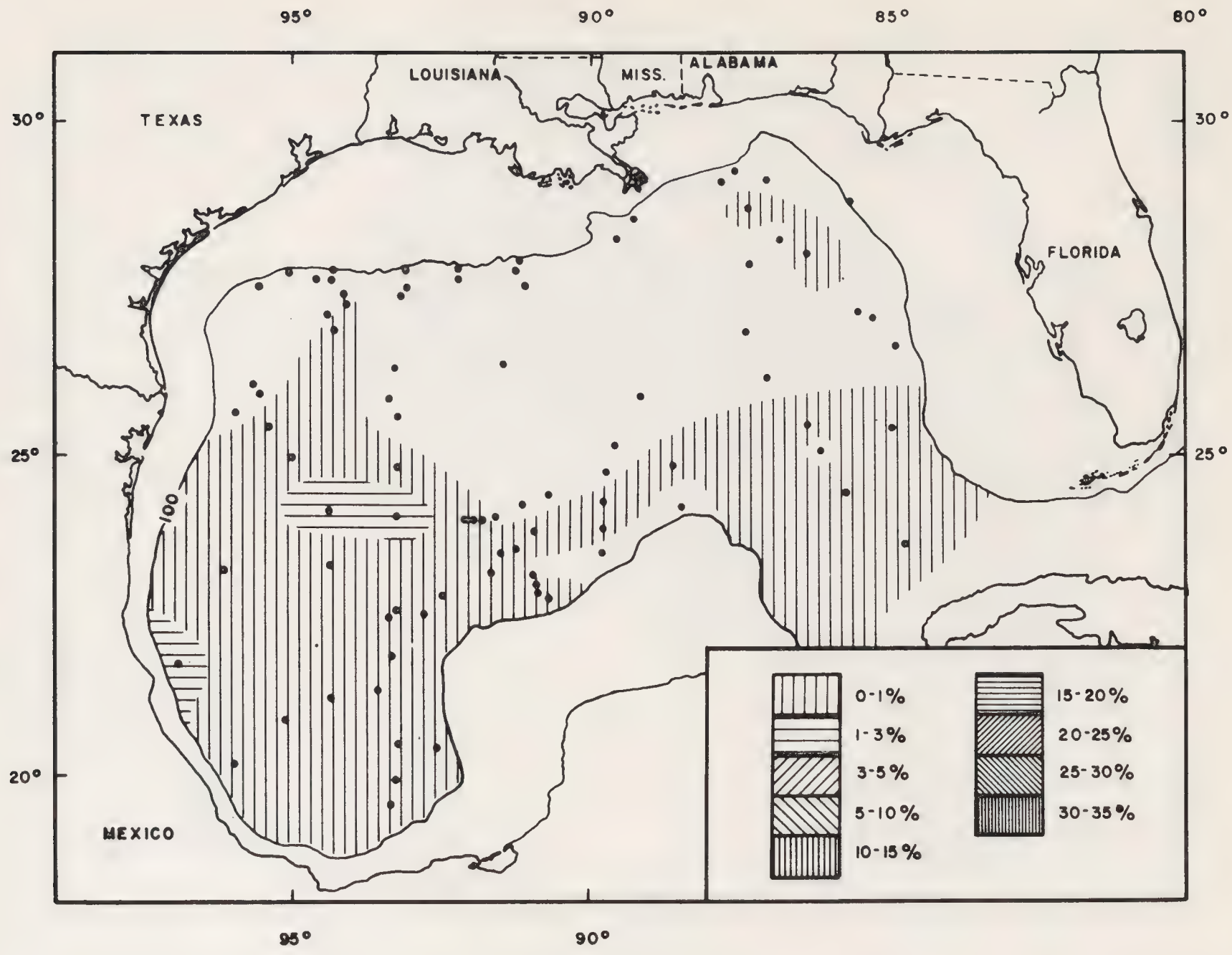

Figure 13. Relative abundance of *Globigerina digitata.*

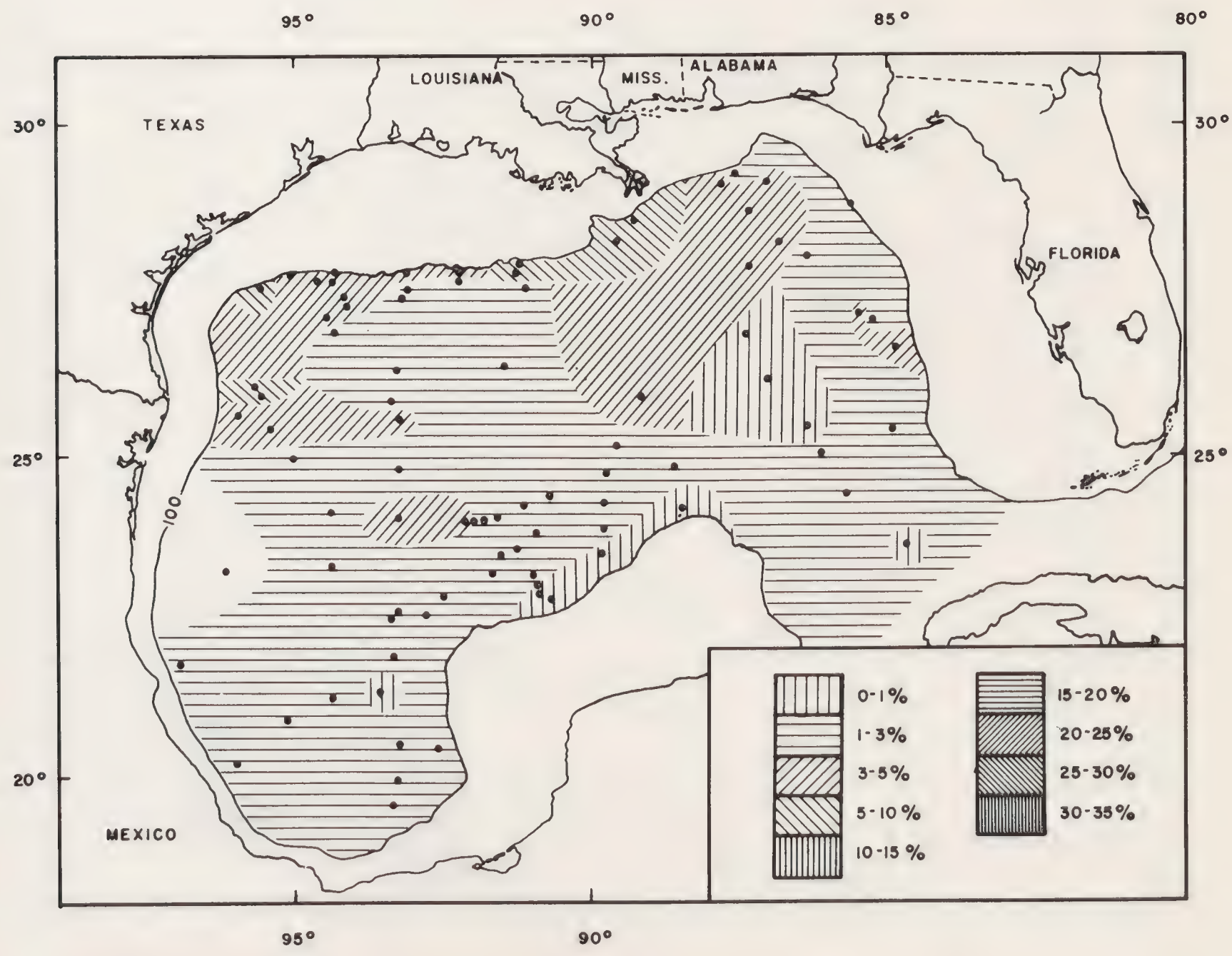

Figure 14. Relative abundance of *Globigerina falconensis.*

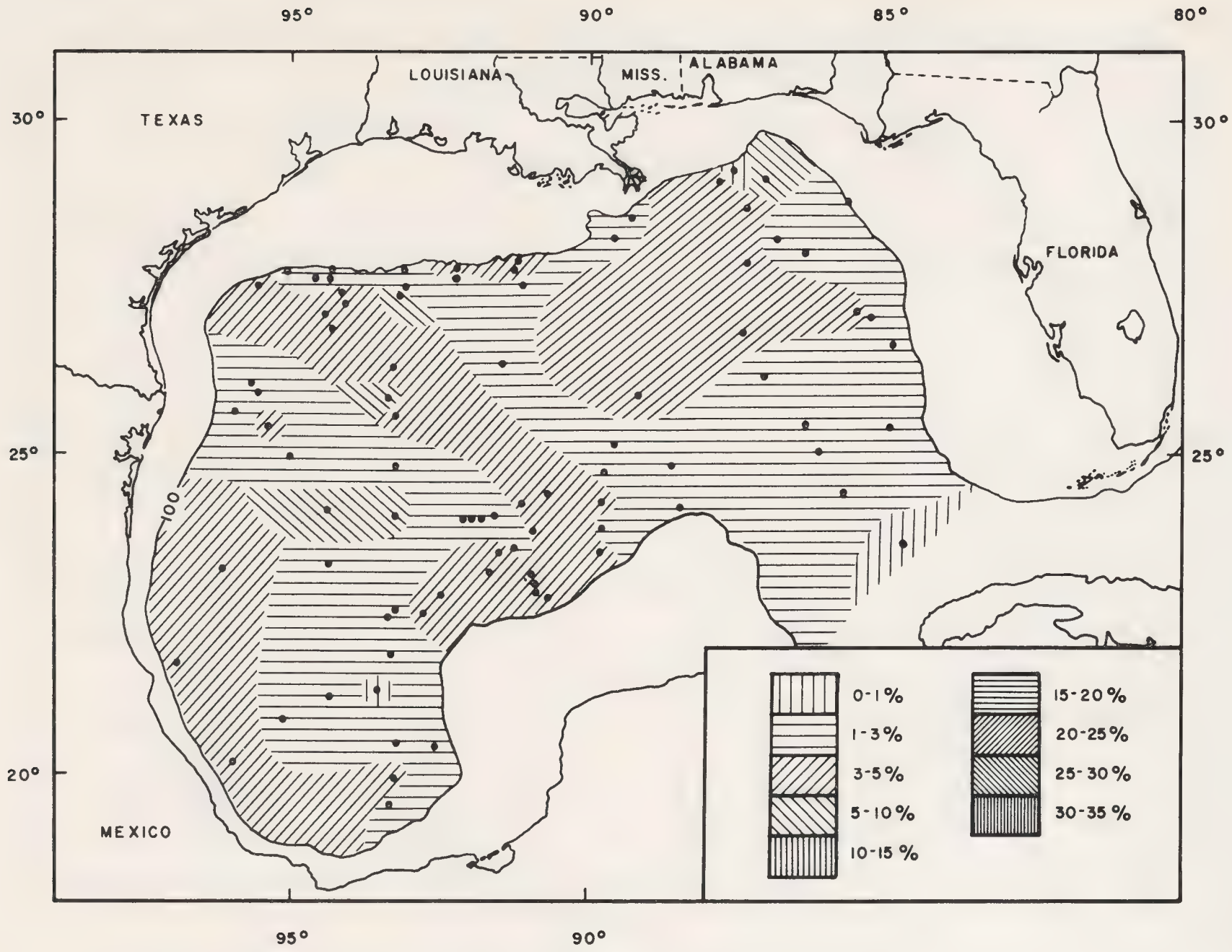

Figure 15. Relative abundance of the *Globigerina falconensis* morphological variant with reduced final chamber.

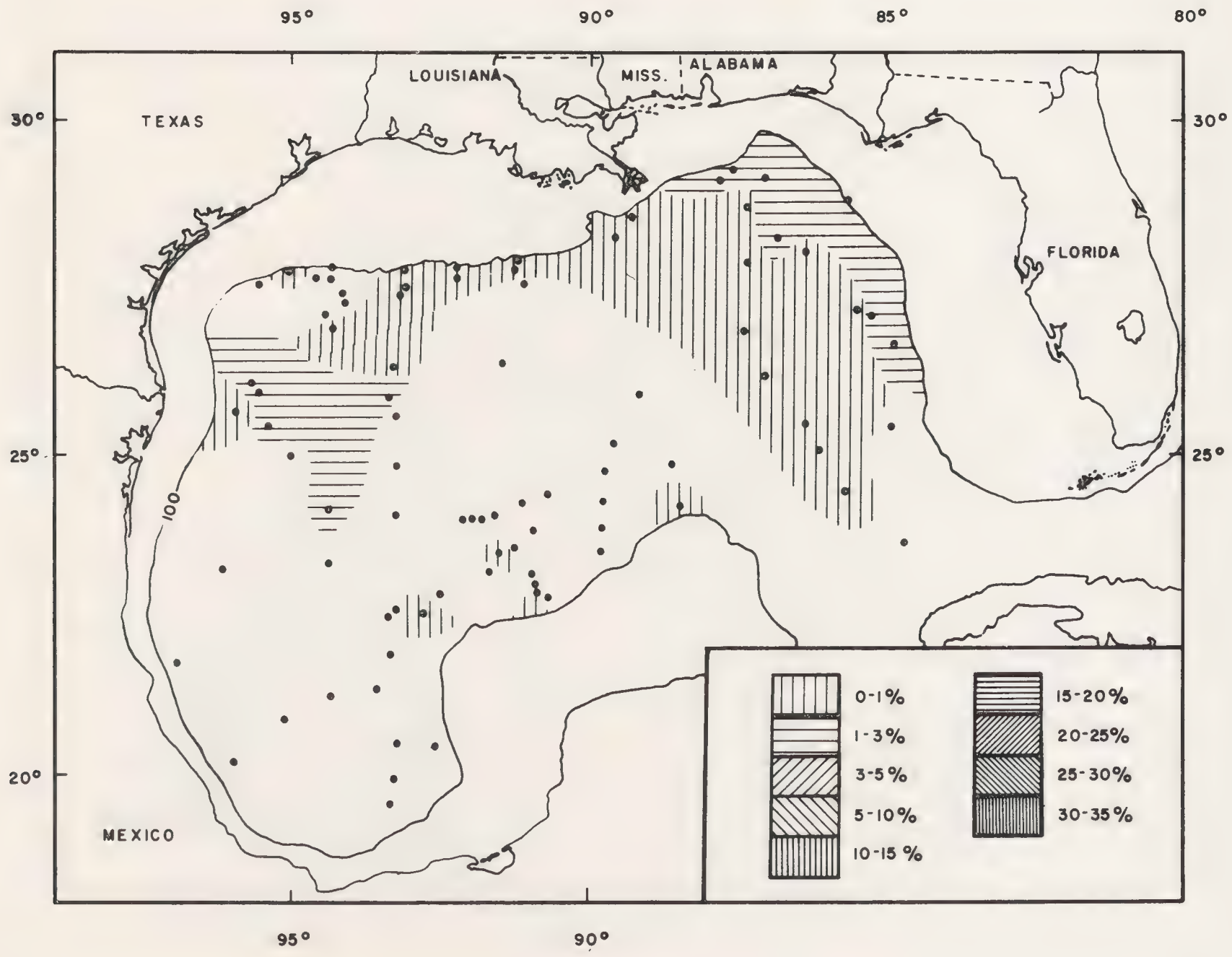

Figure 16. Relative abundance of *Globigerina pachyderma.*

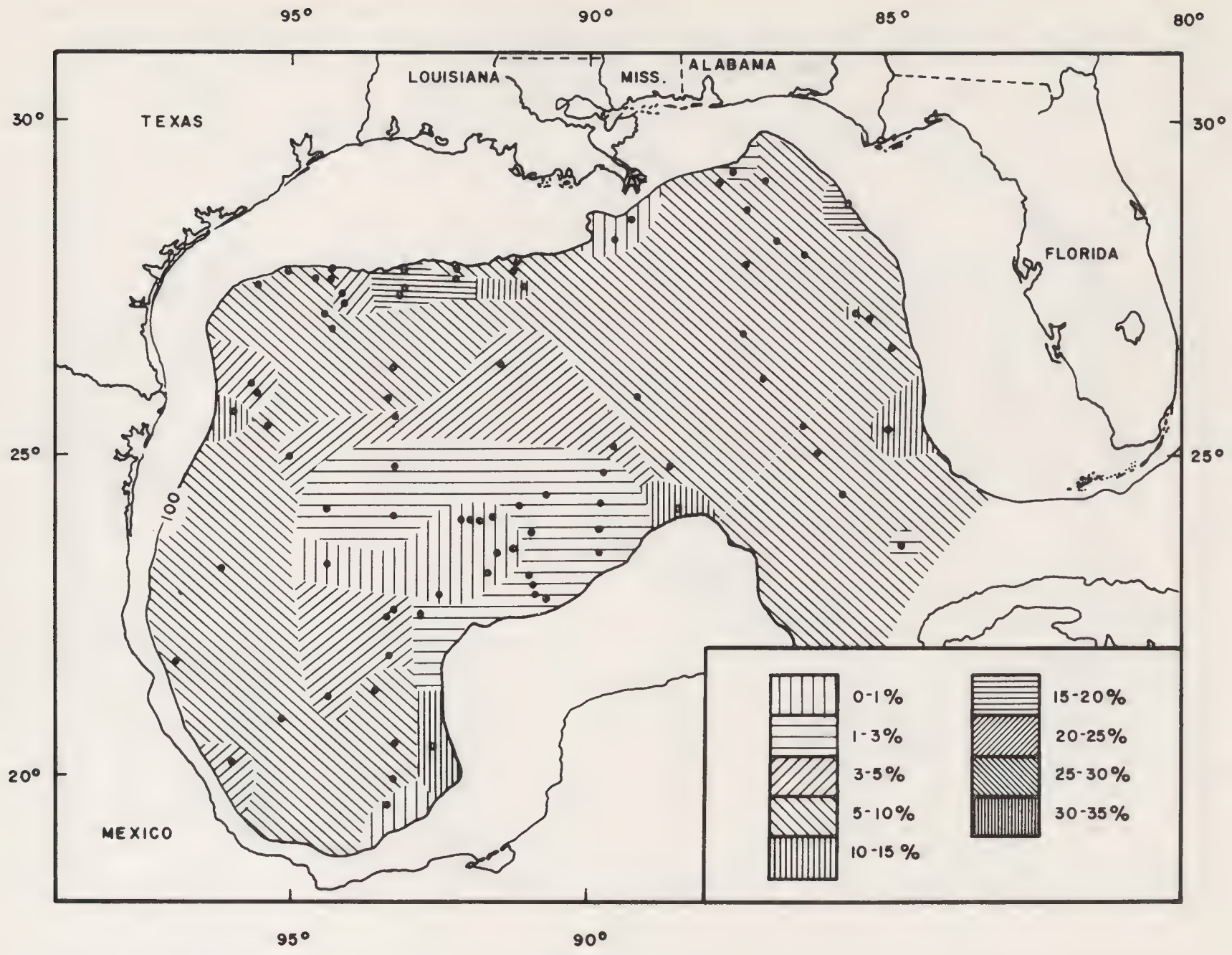

Figure 17. Relative abundance of *Globigerina quinqueloba.*

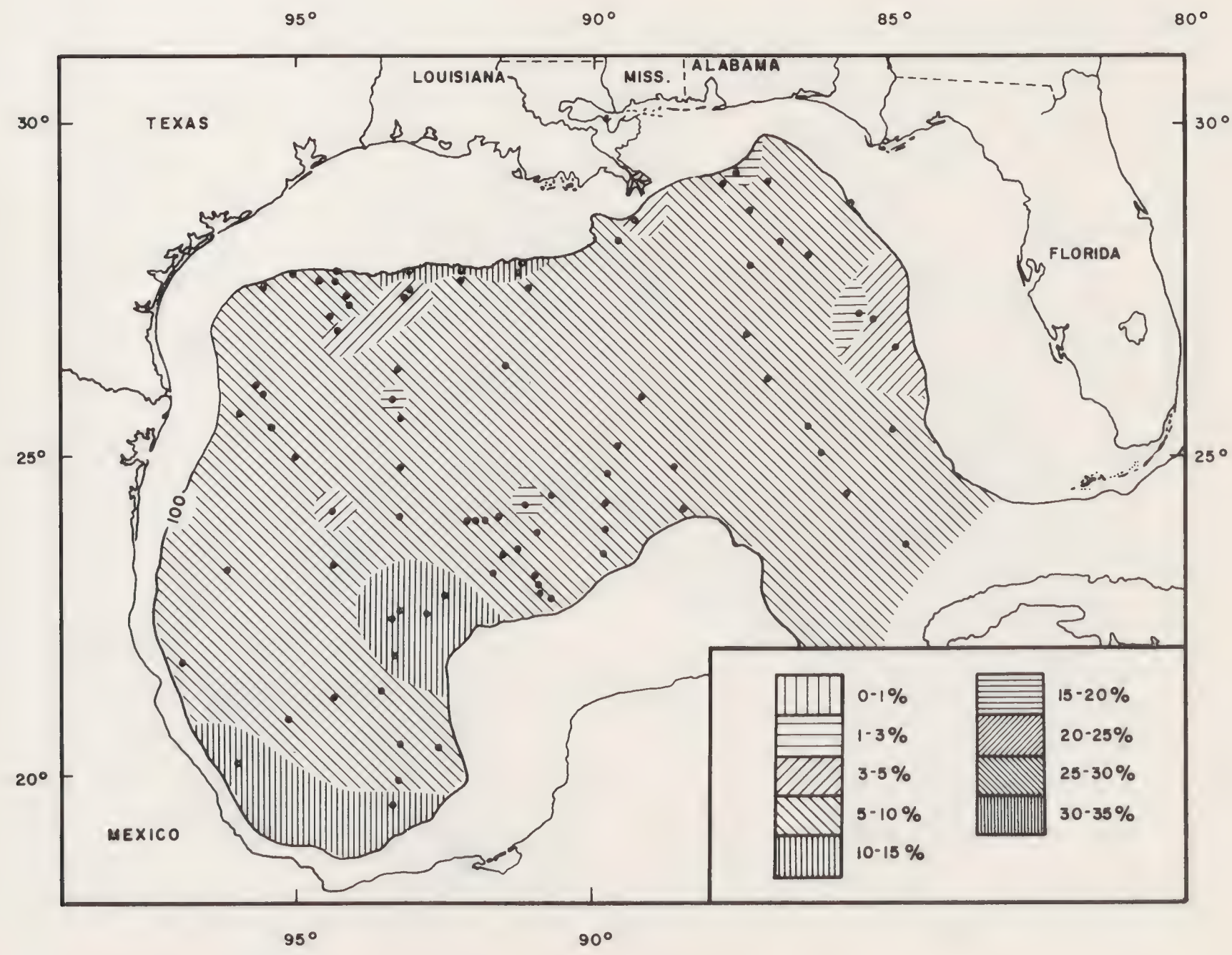

Figure 18. Relative abundance of *Globigerina rubescens.*

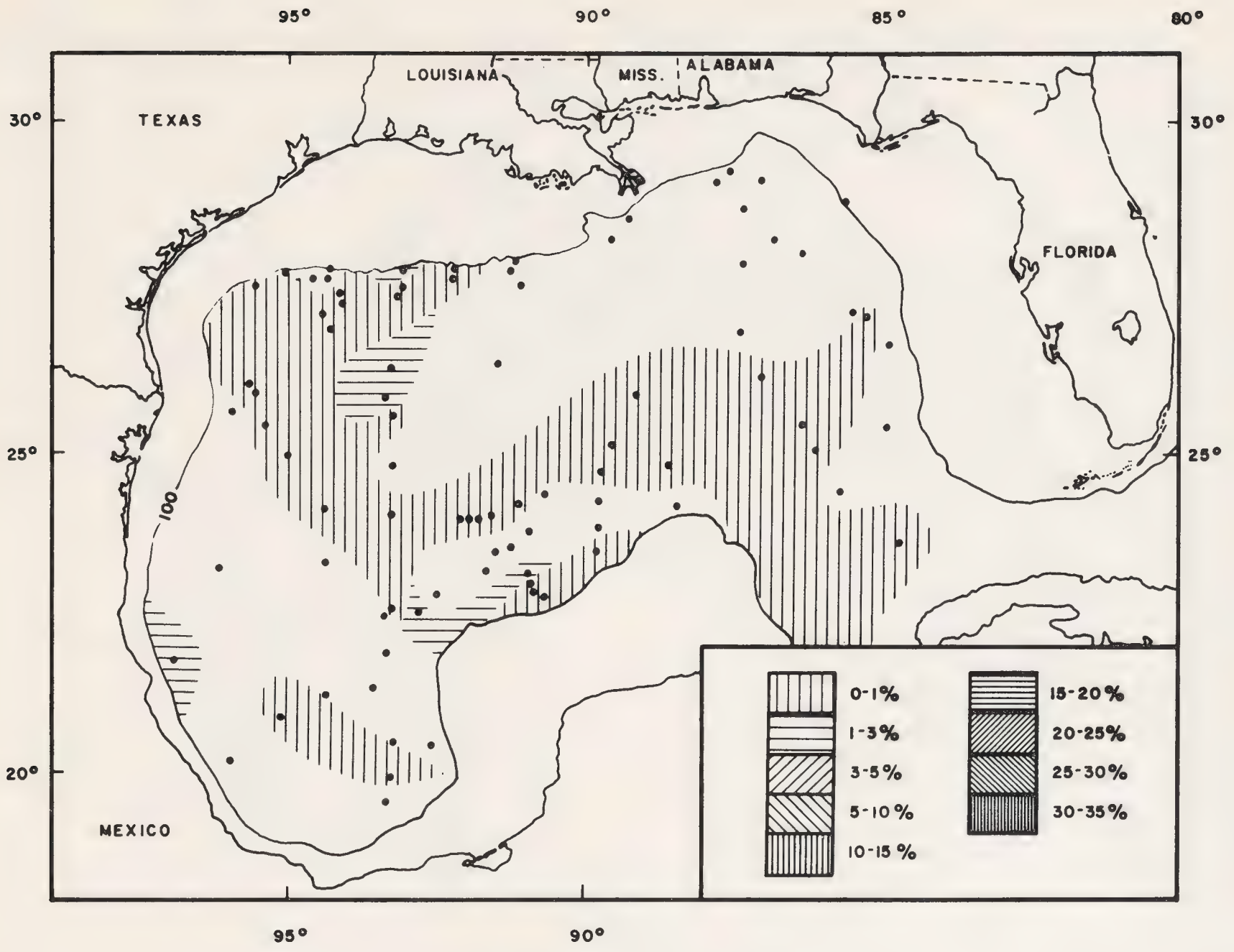

Figure 19. Relative abundance of *Globigerina* sp.

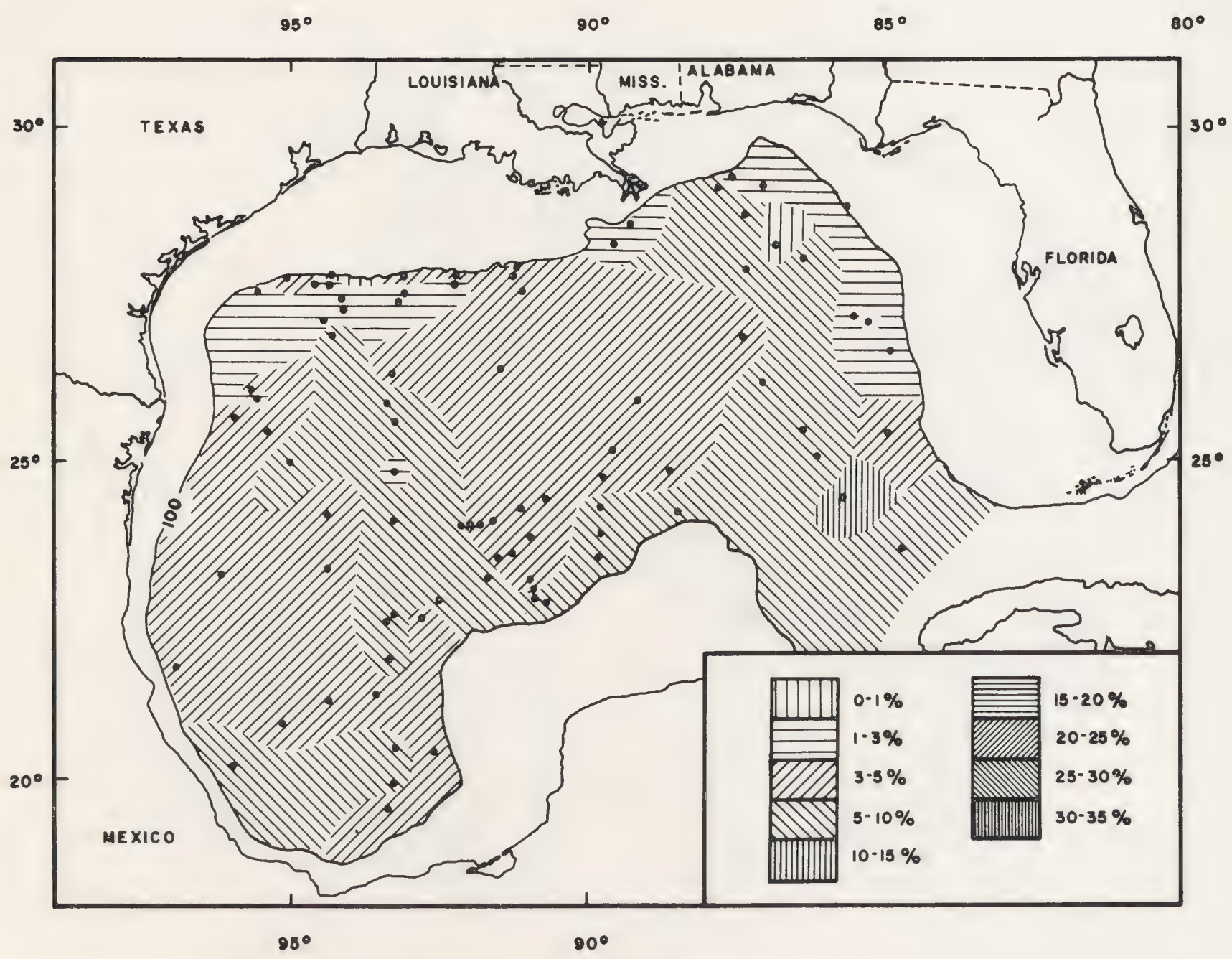

Figure 20. Relative abundance of *Globigerinella siphonifera.*

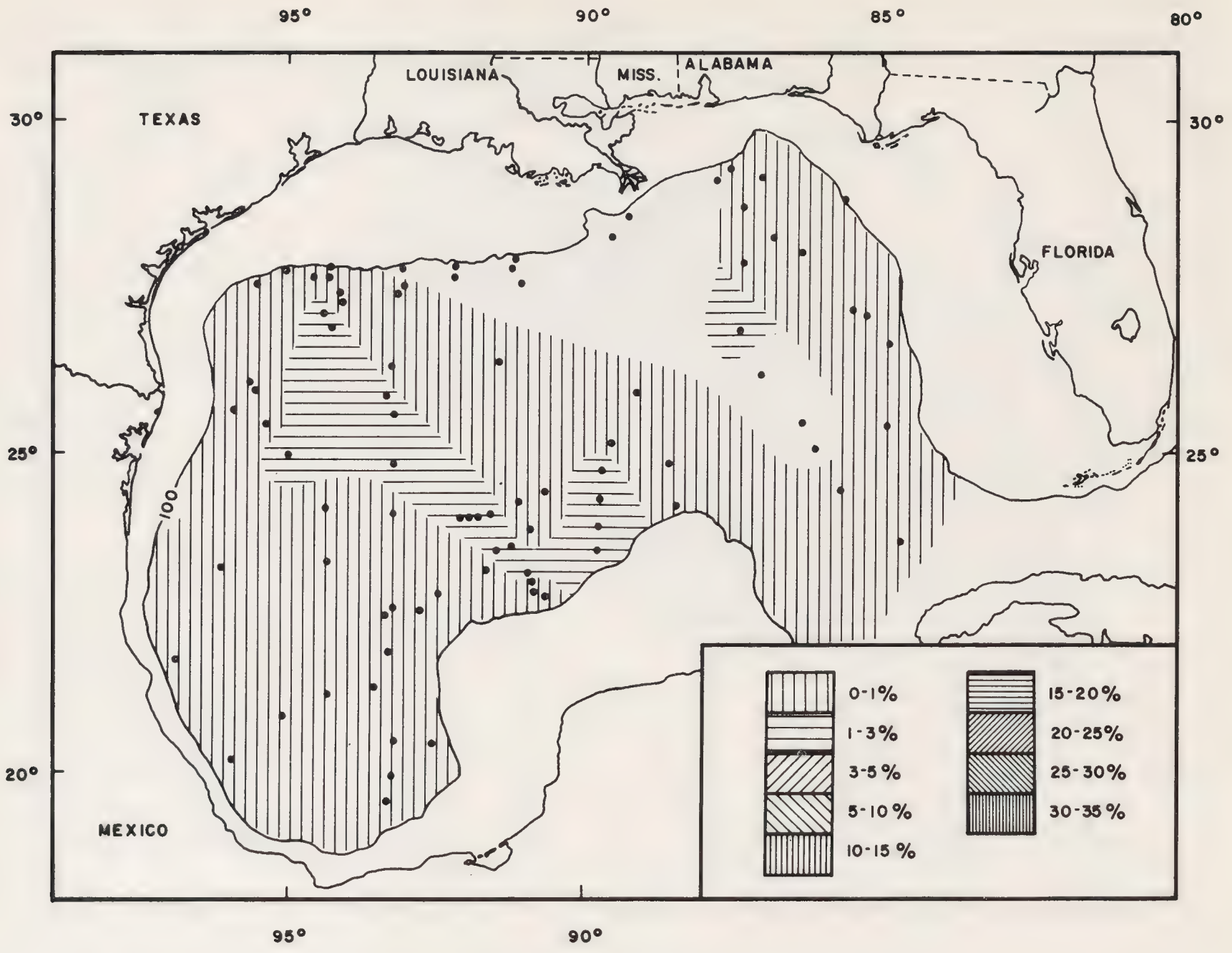

Figure 21. Relative abundance of *Globigerinoides conglobatus.*

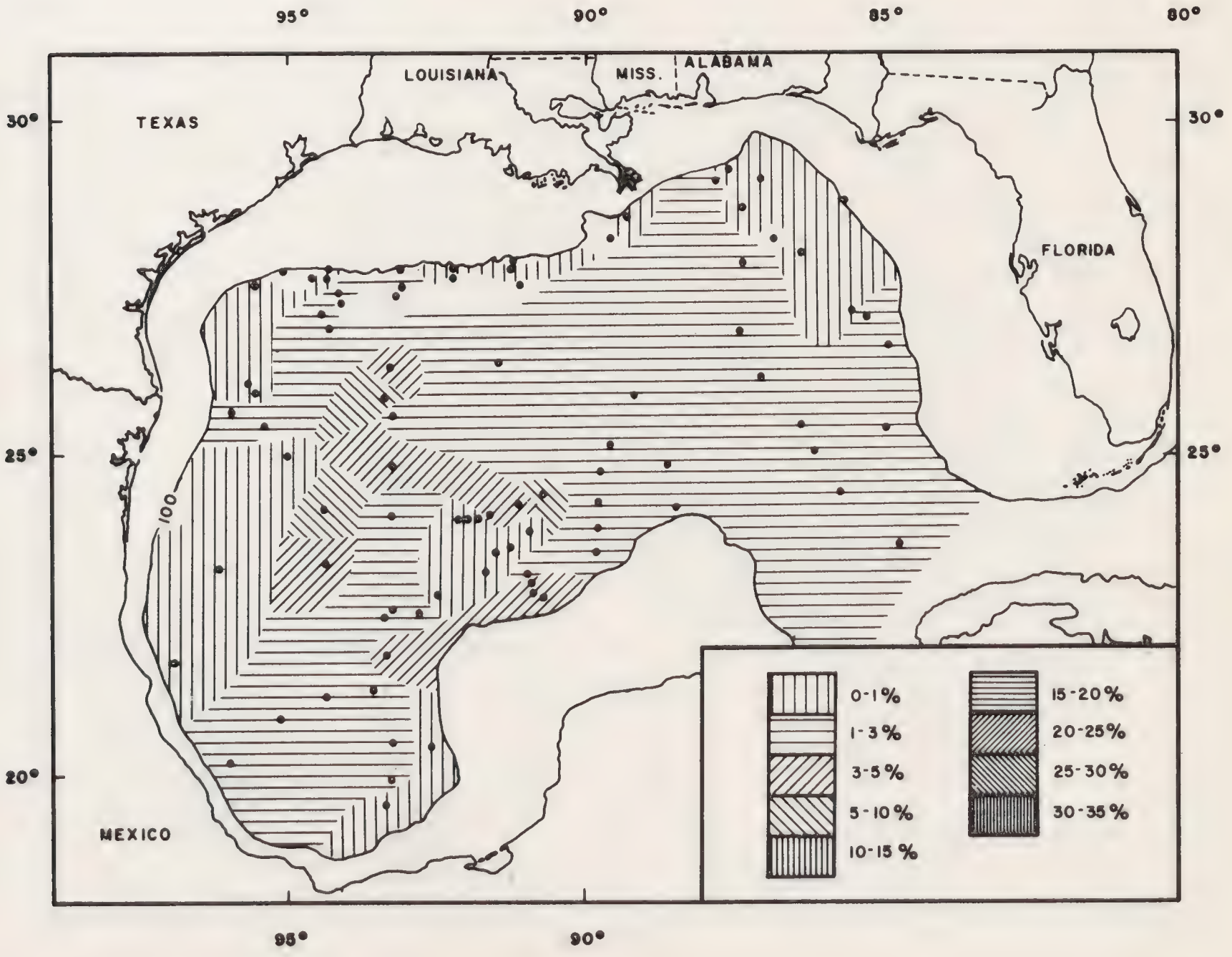

Figure 22. Relative abundance of *Globigerinoides elongatus.*

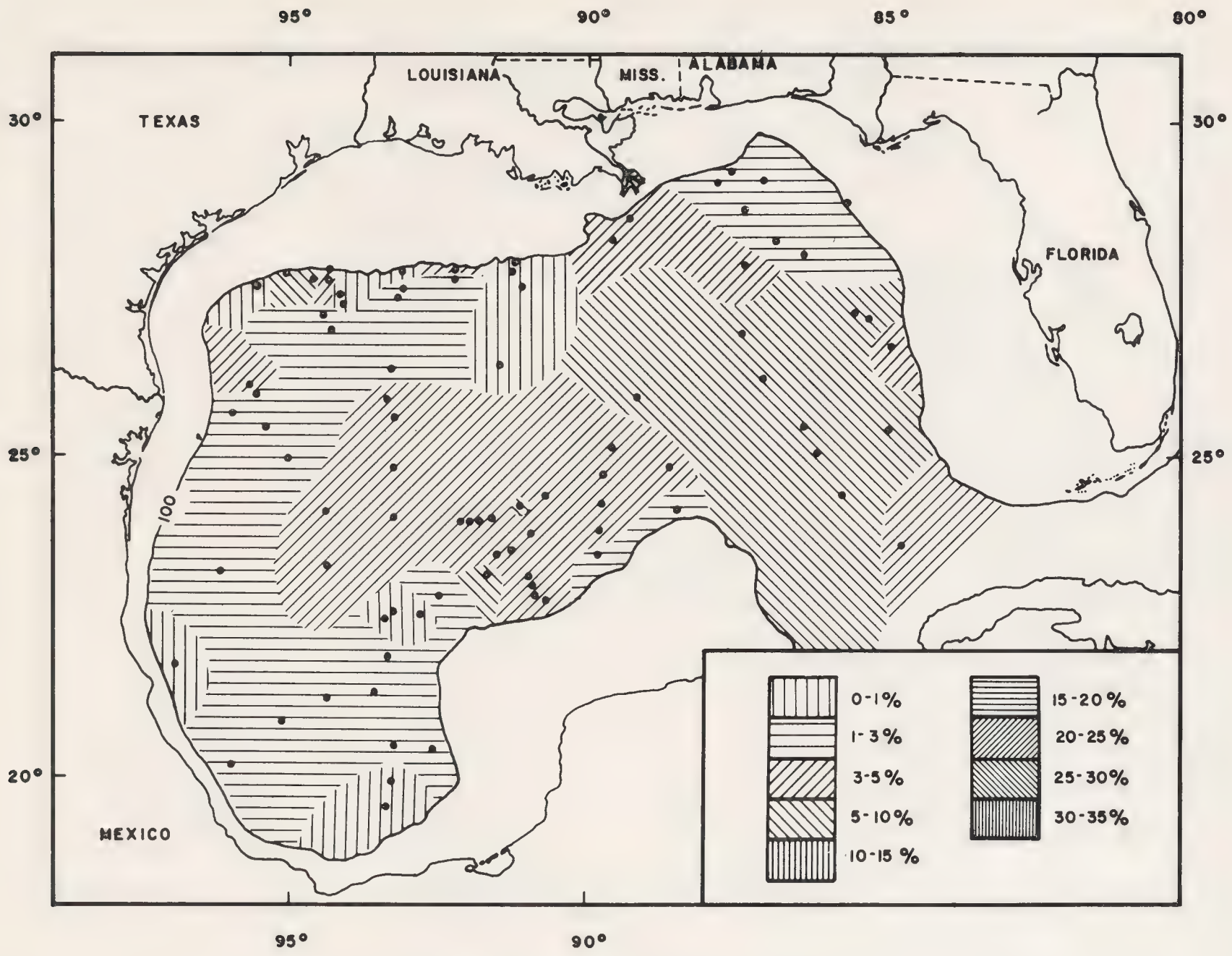

Figure 23. Relative abundance of *Globigerinoides quadrilobatus quadrilobatus.*

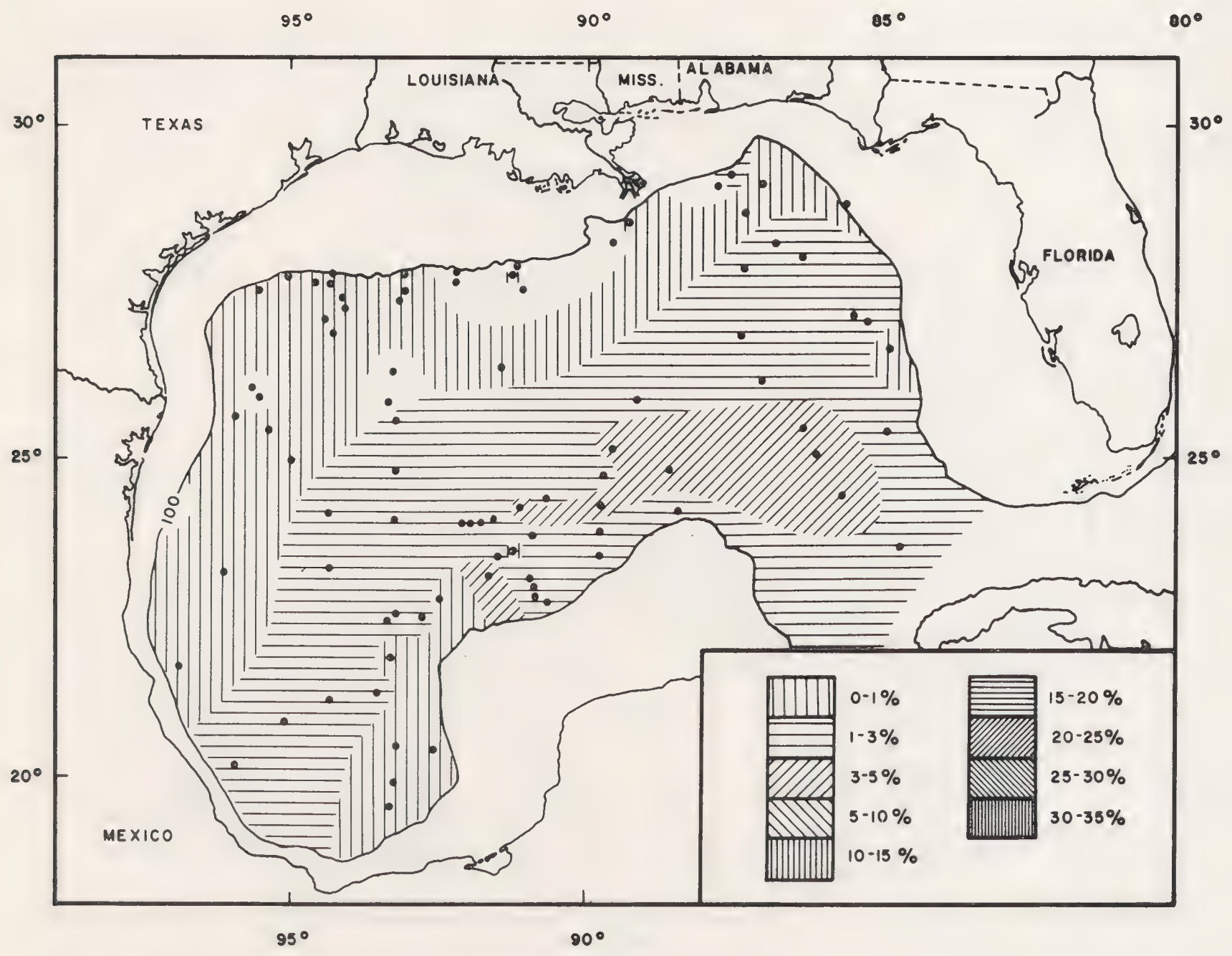

Figure 24. Relative abundance of *Globigerinoides quadrilobatus sacculifer.*

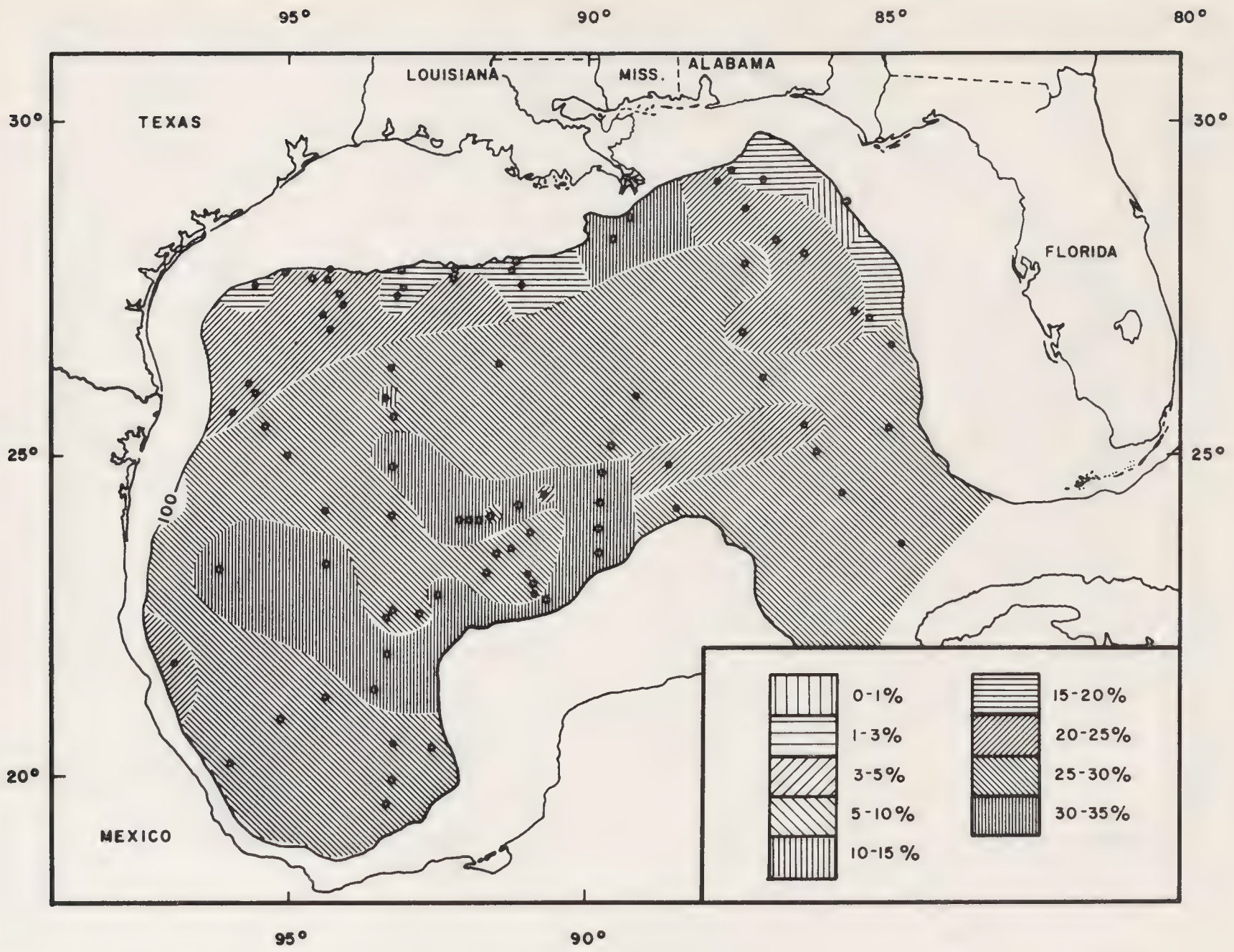

Figure 25. Relative abundance of *Globigerinoides ruber.*

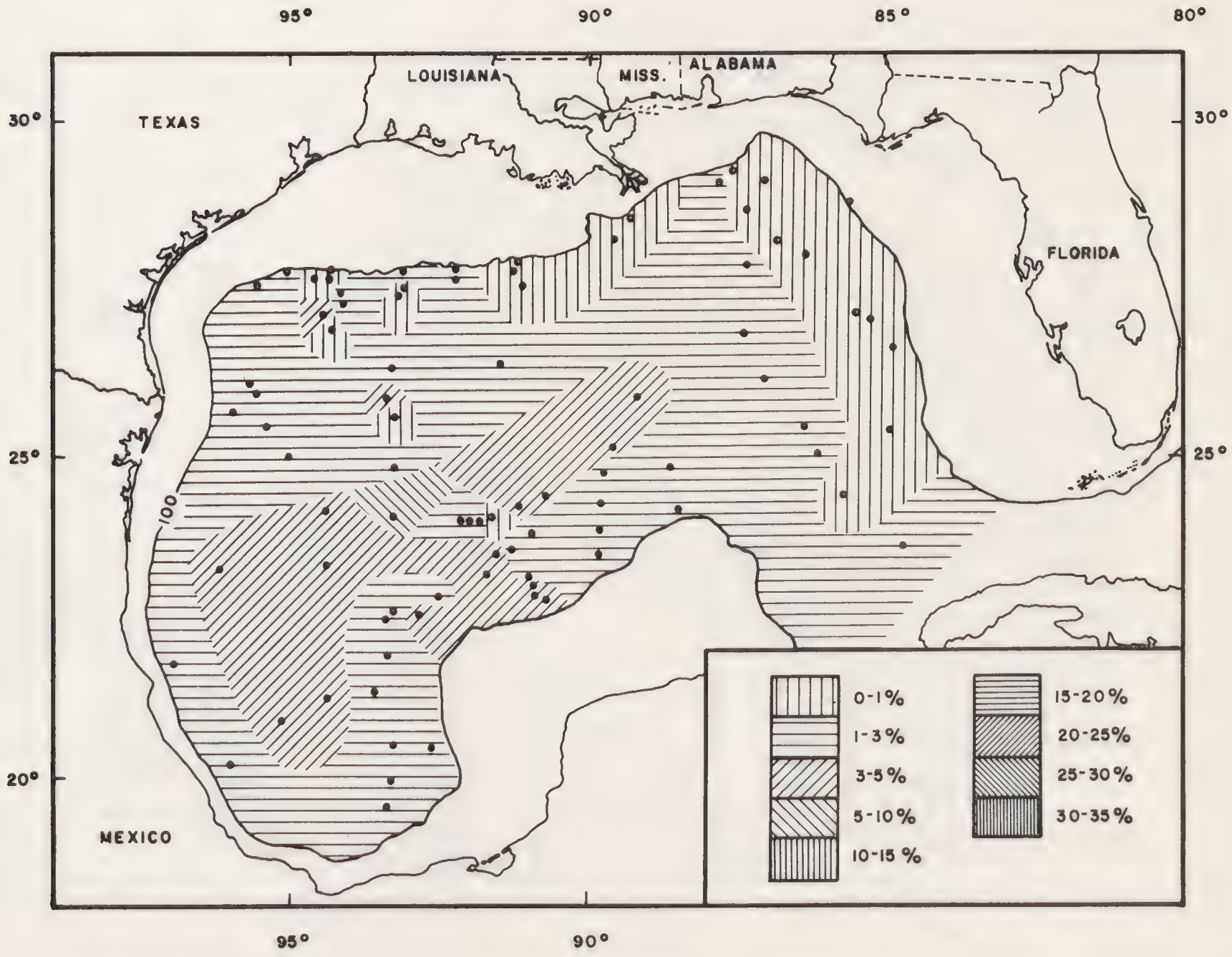

Figure 26. Relative abundance of *Globigerinoides tenellus.*

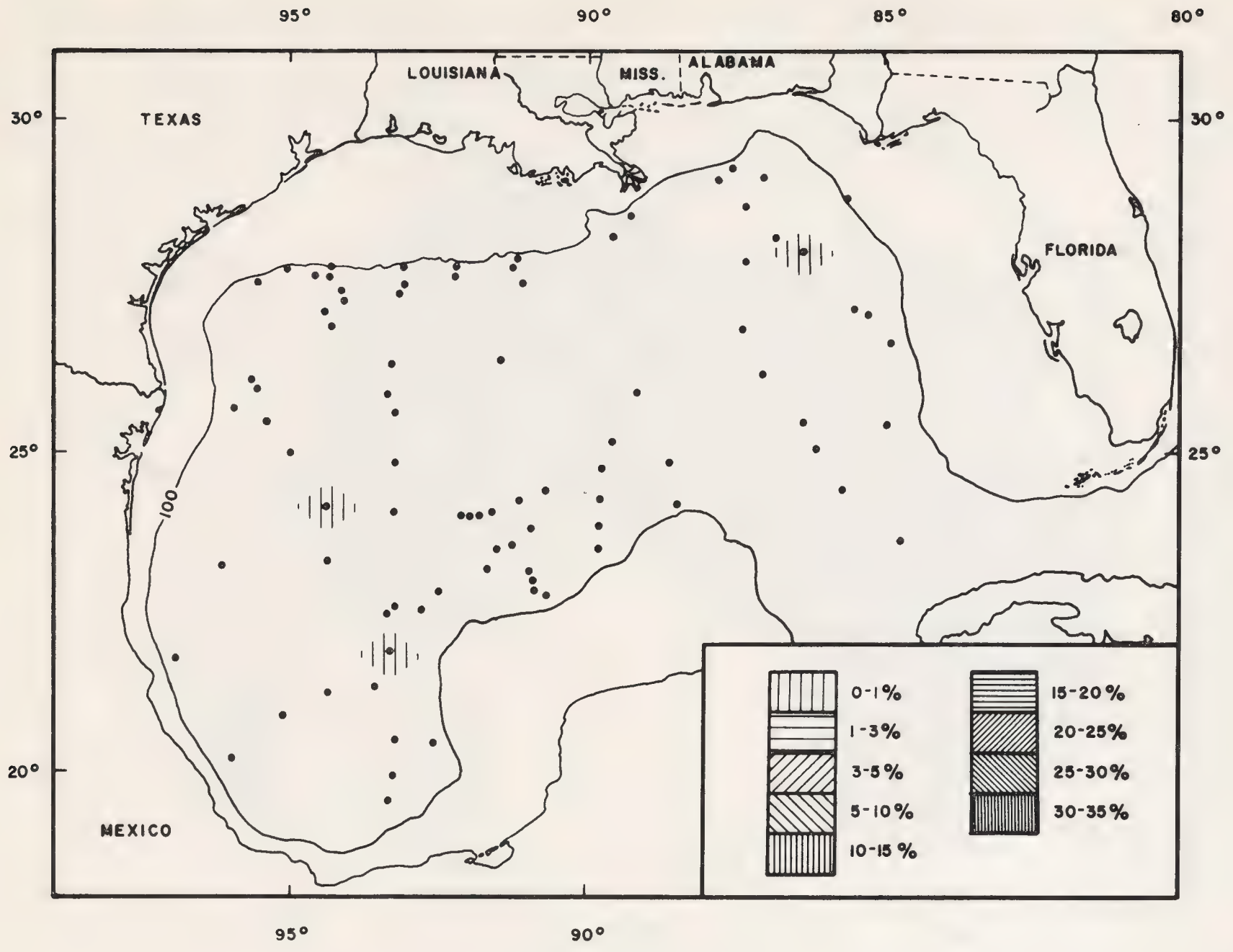

Figure 27. Relative abundance of *Orbulina bilobata.*

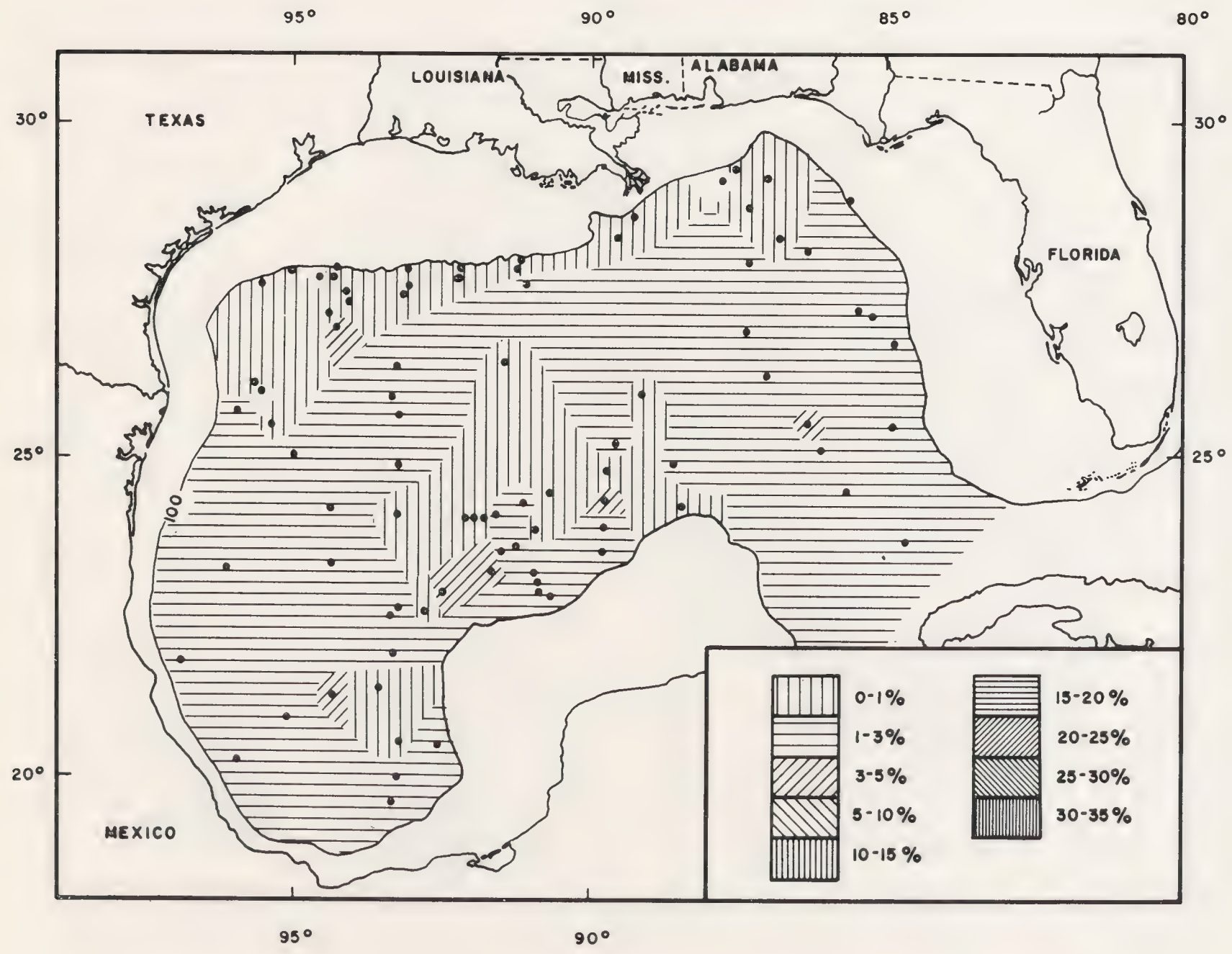

Figure 28. Relative abundance of *Orbulina universa.*

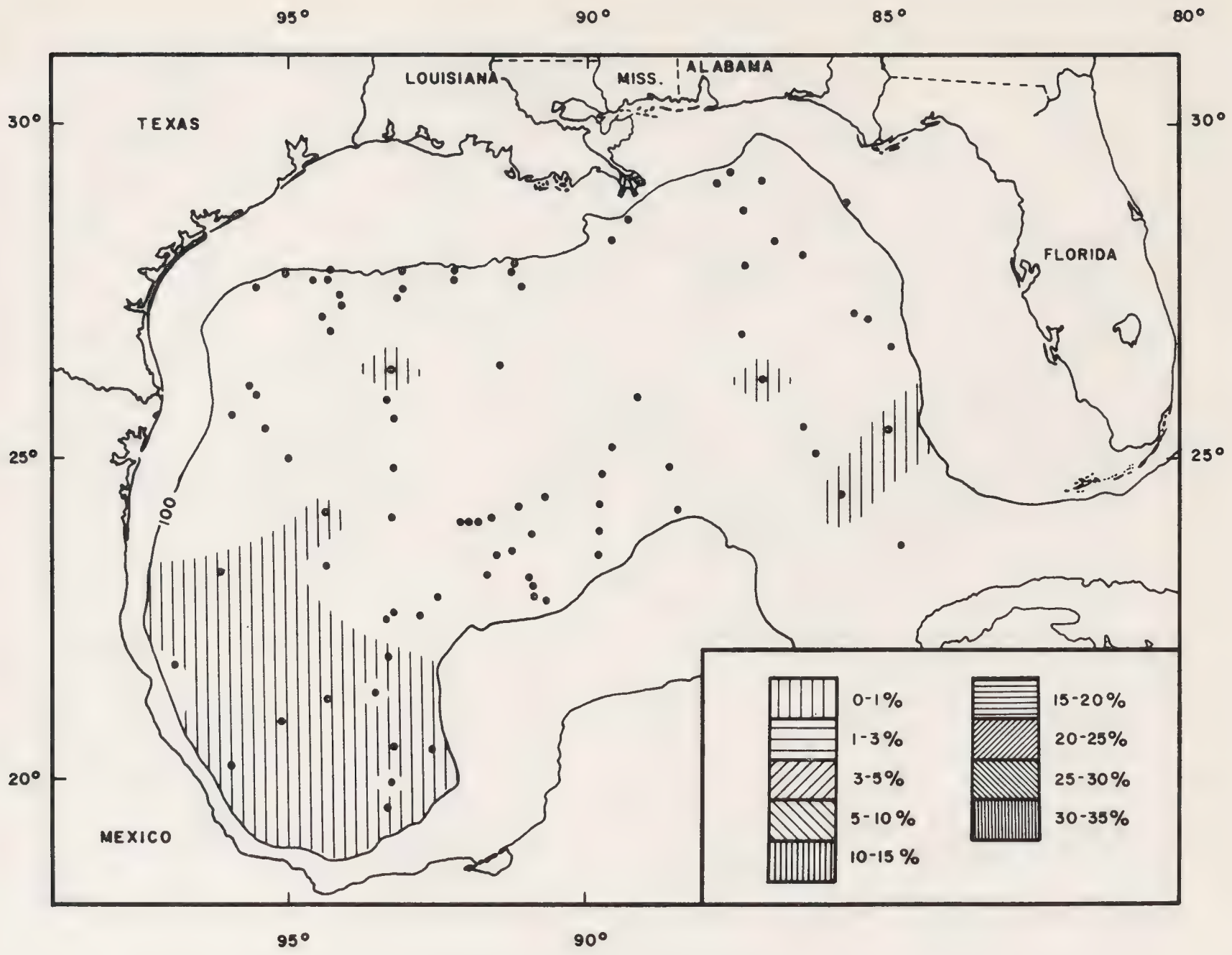

Figure 29. Relative abundance of *Hastigerina pelagica.*

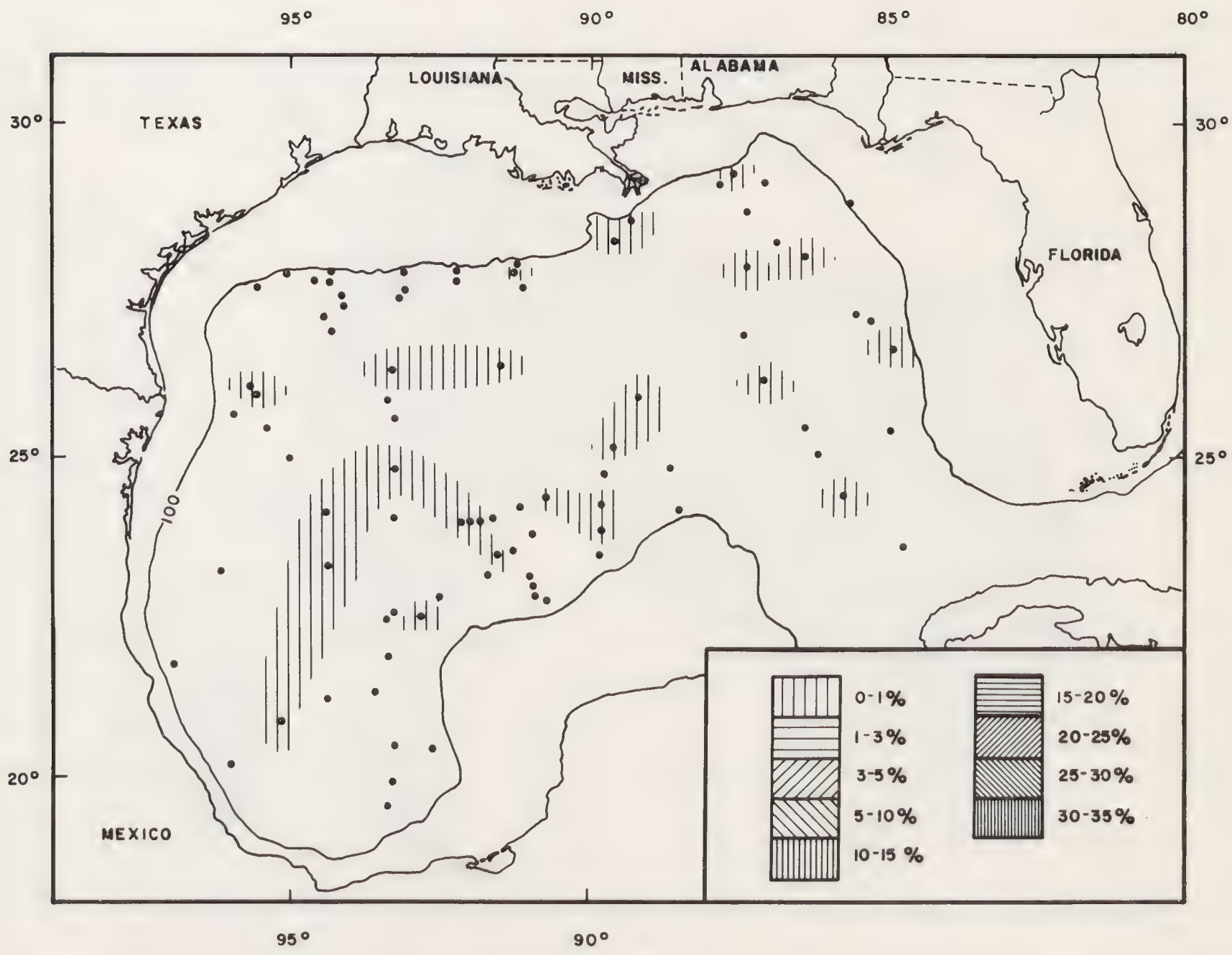

Figure 30. Relative abundance of *Sphaeroidinella dehiscens.*

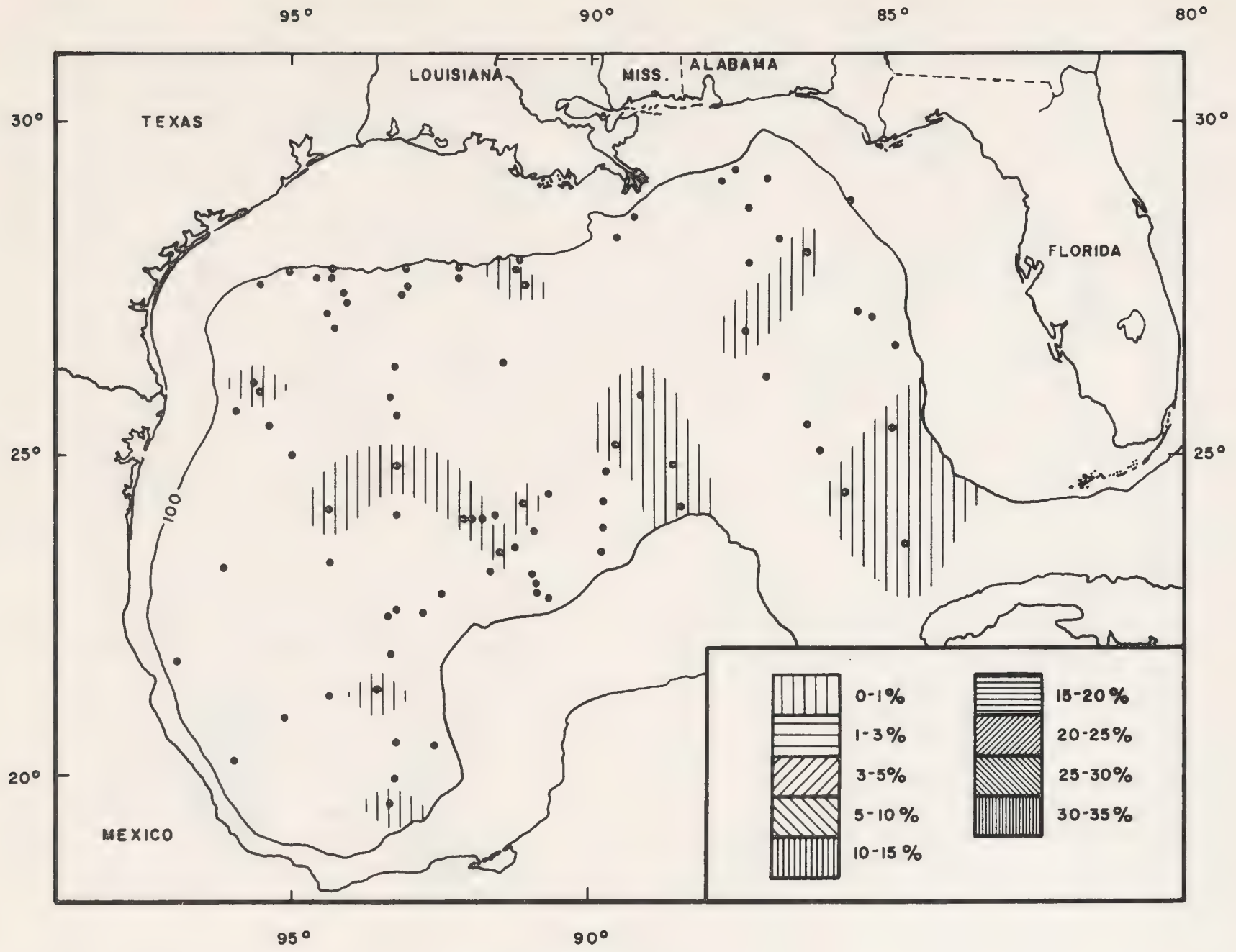

Figure 31. Relative abundance of *Candeina nitida.*

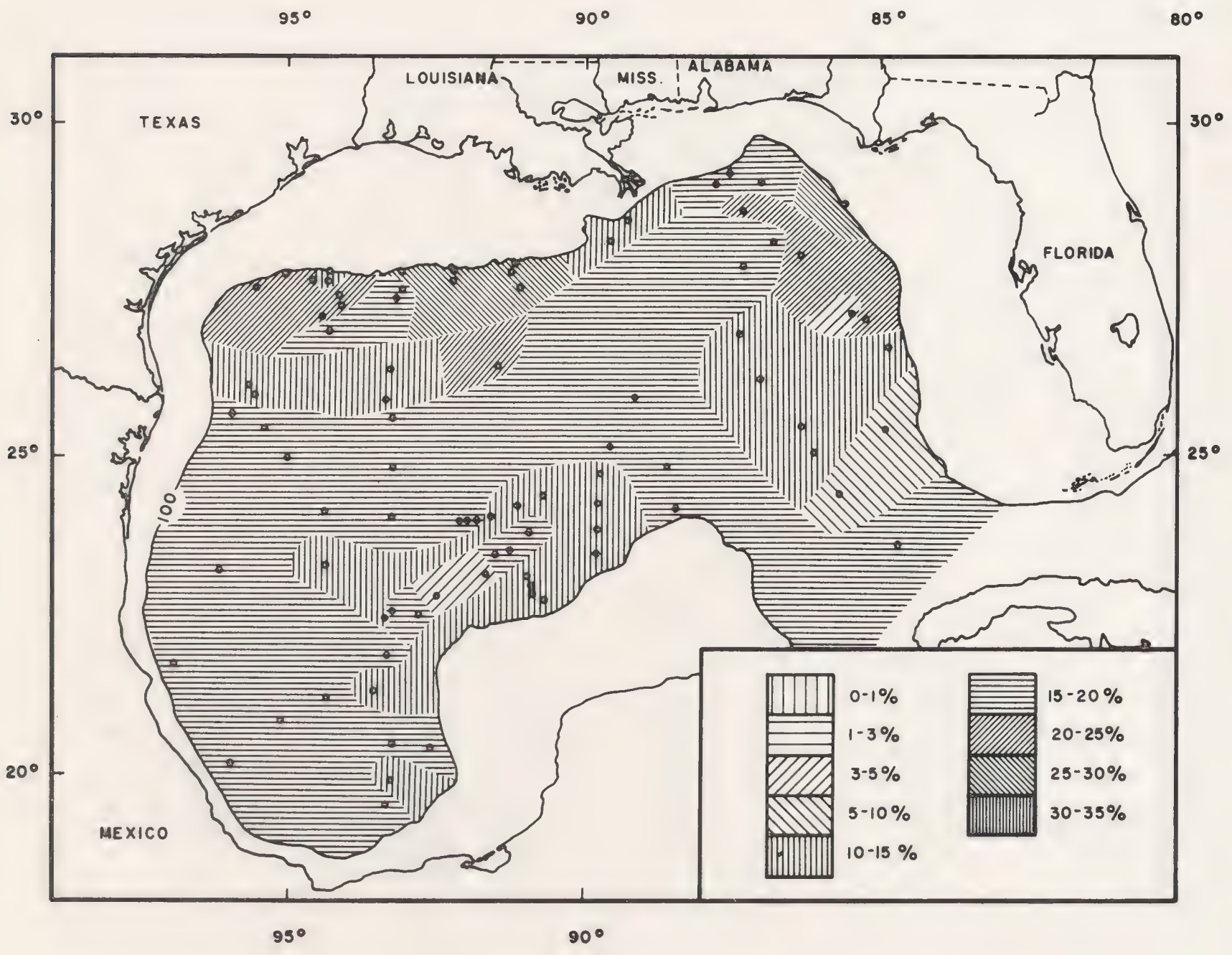

Figure 32. Relative abundance of *Globigerinita glutinata.*

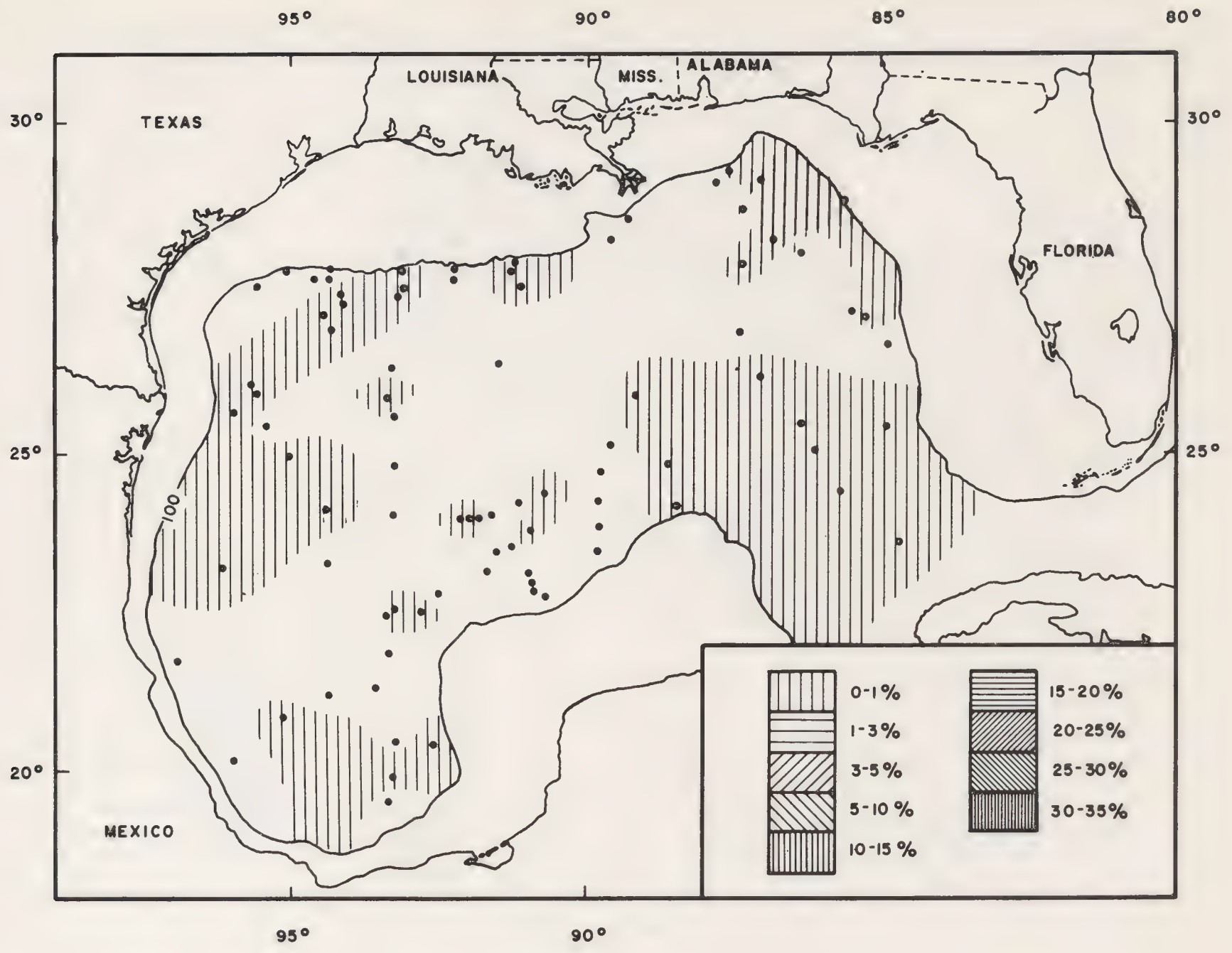

Figure 33. Relative abundance of *Globigerinita iota.*

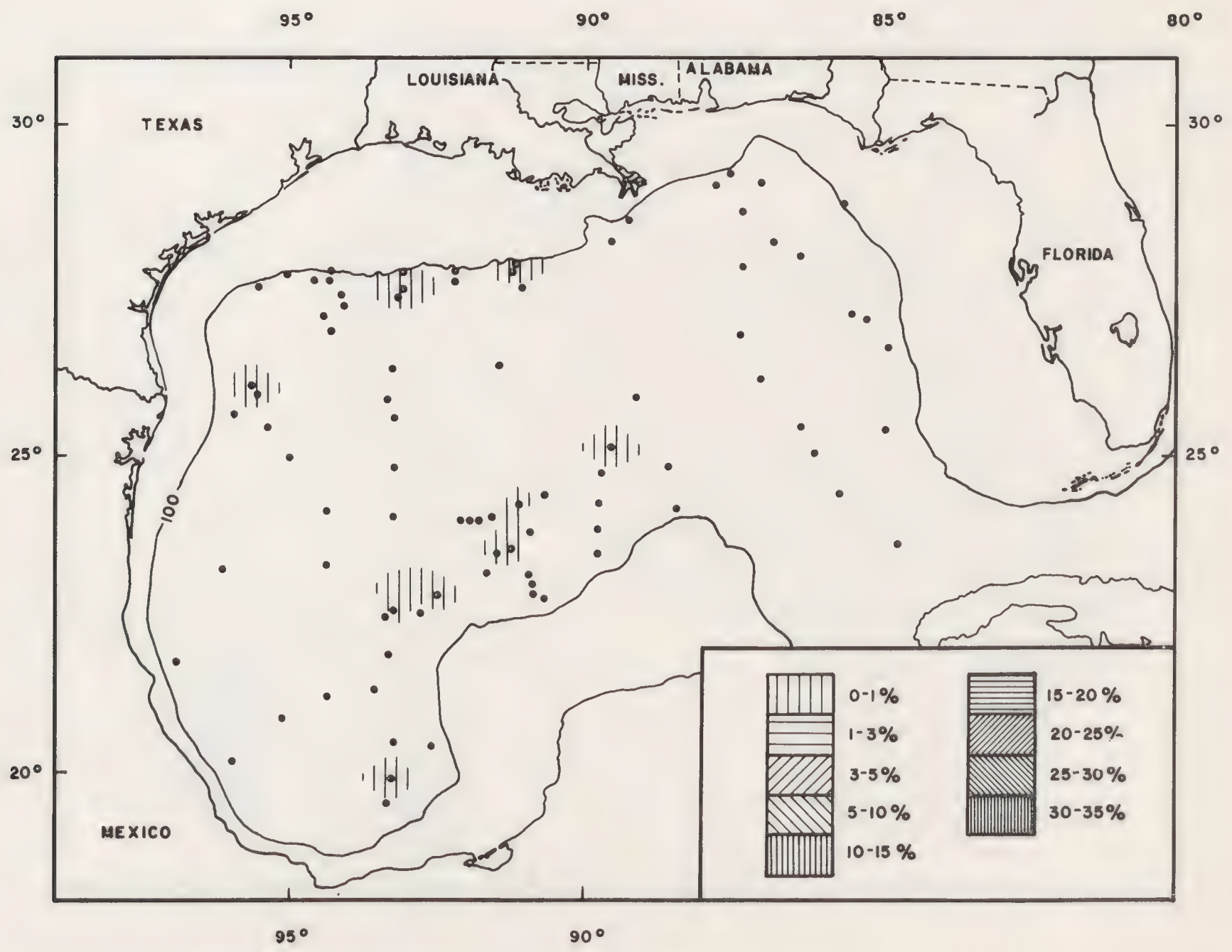

Figure 34. Relative abundance of *Globigerinita uvula.*

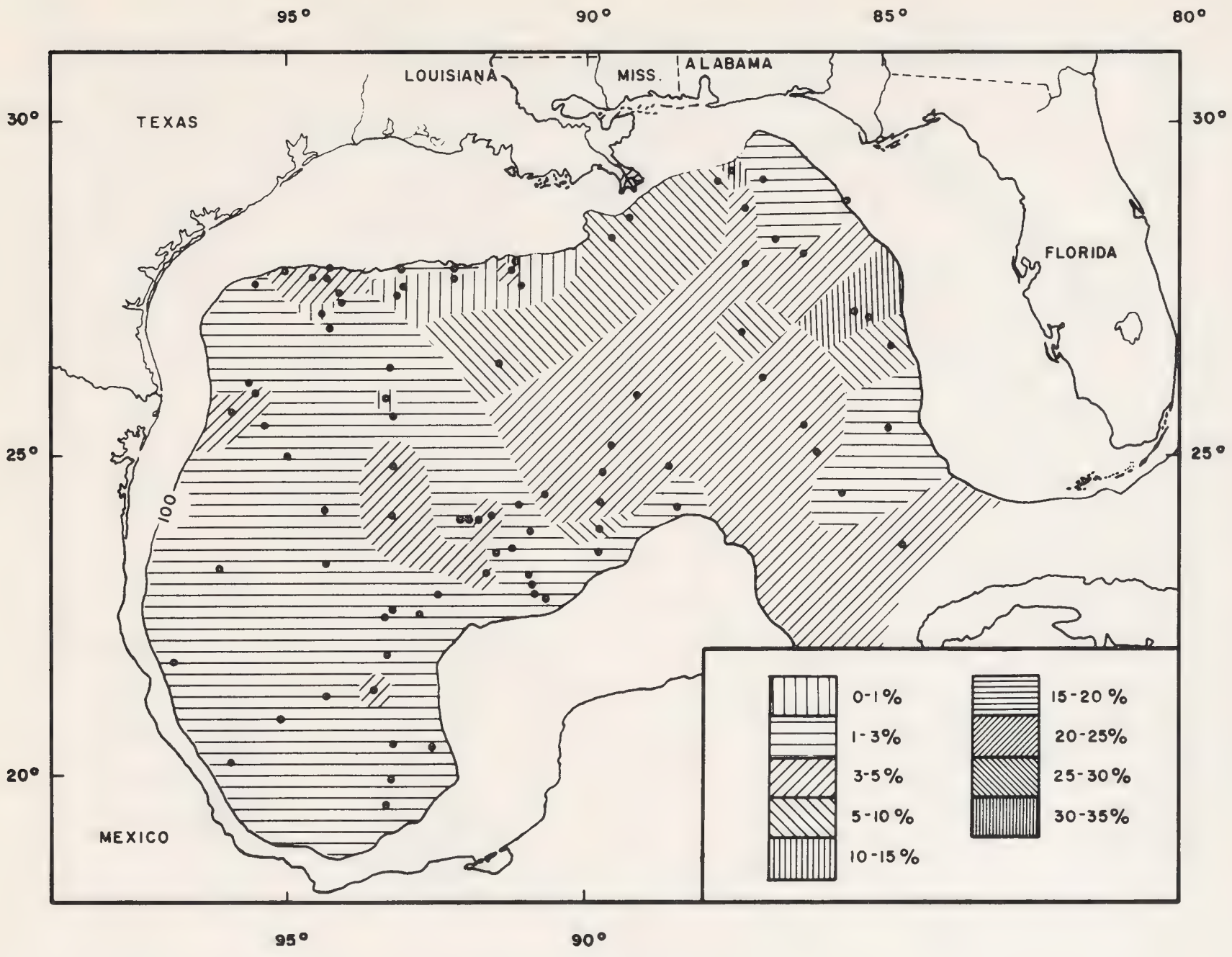

Figure 35. Relative abundance of *Globoquadrina dutertrei.*

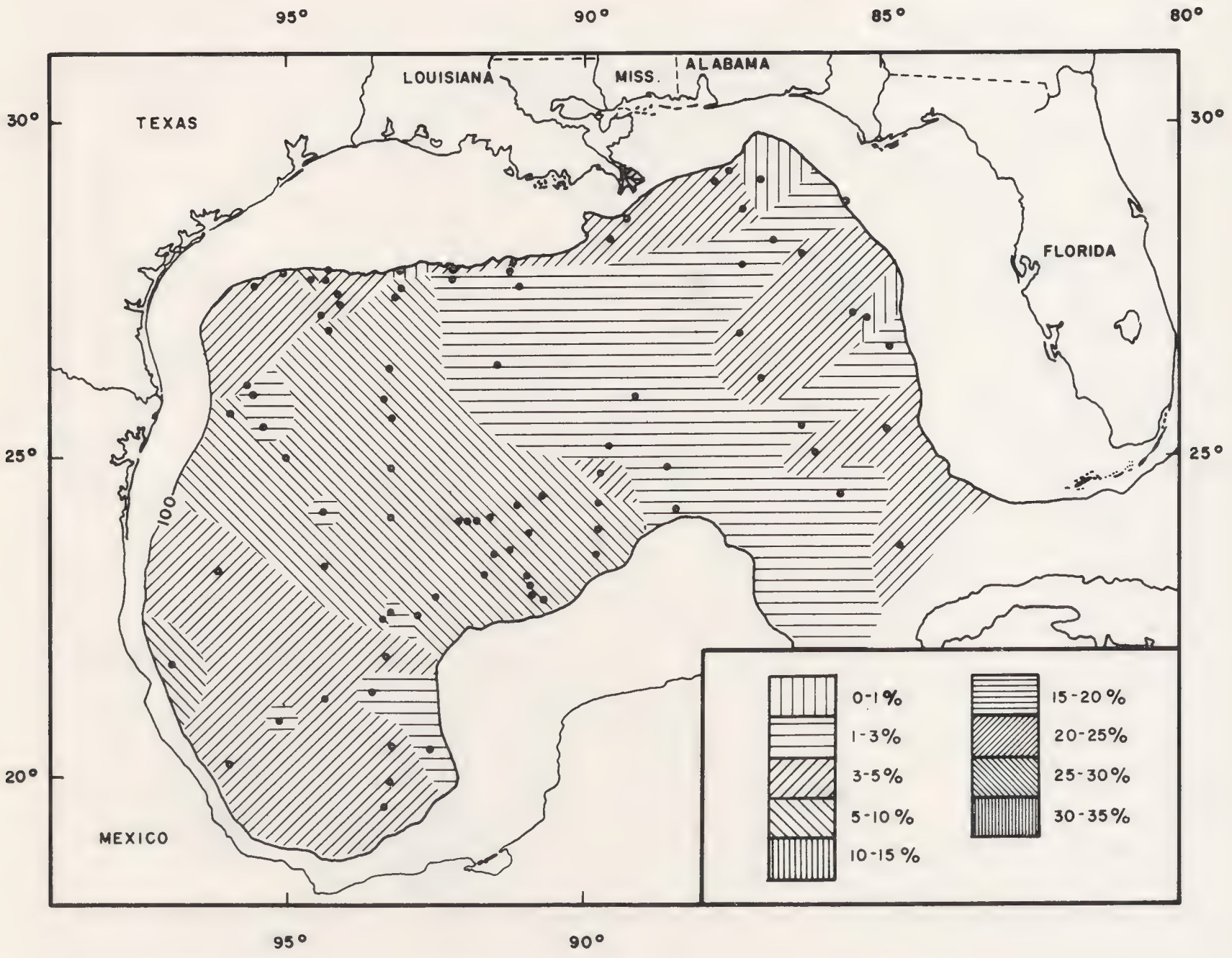

Figure 36. Relative abundance of the *Pulleniatina obliquiloculata* complex.

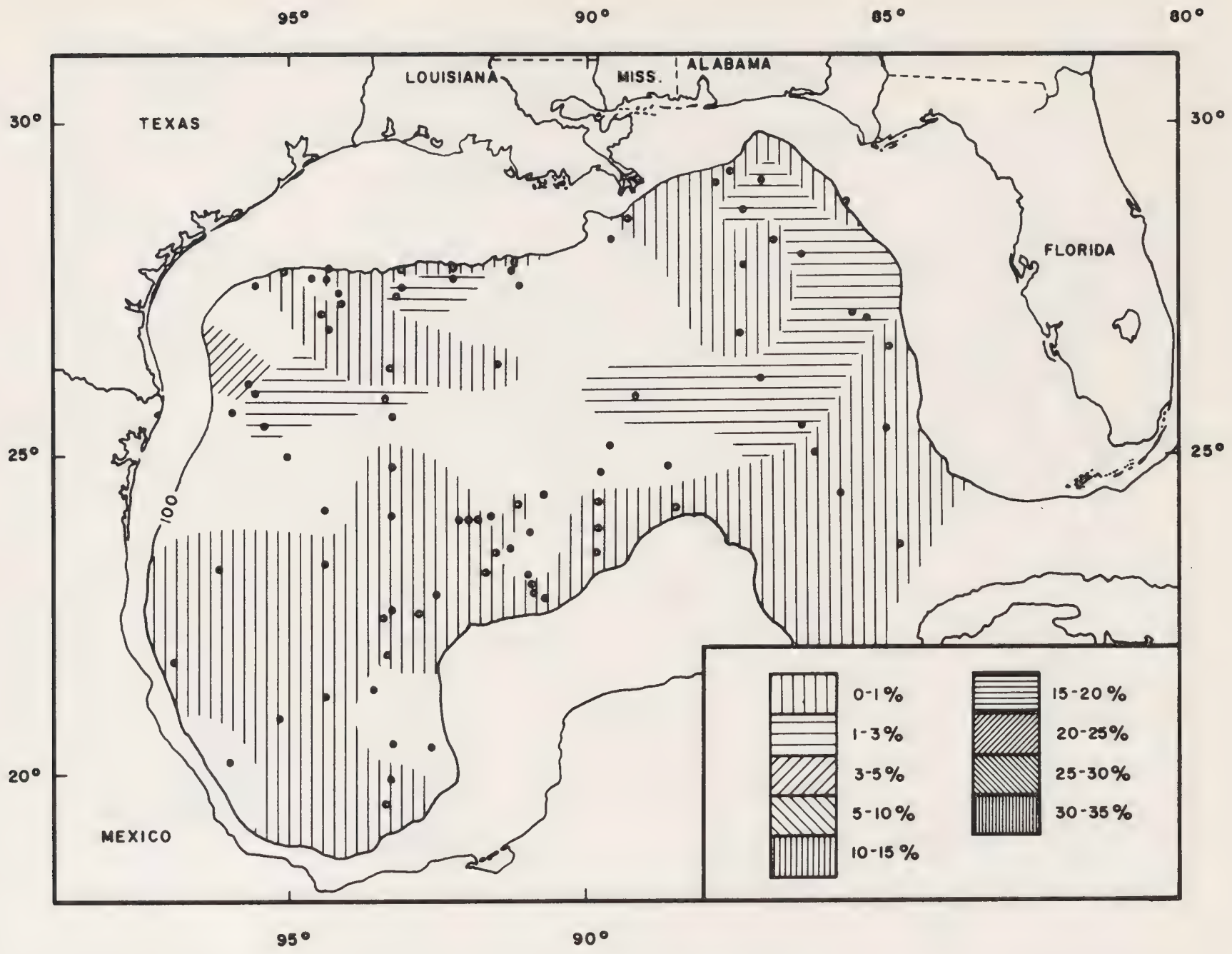

Figure 37. Relative abundance of *Globorotalia crassiformis.*

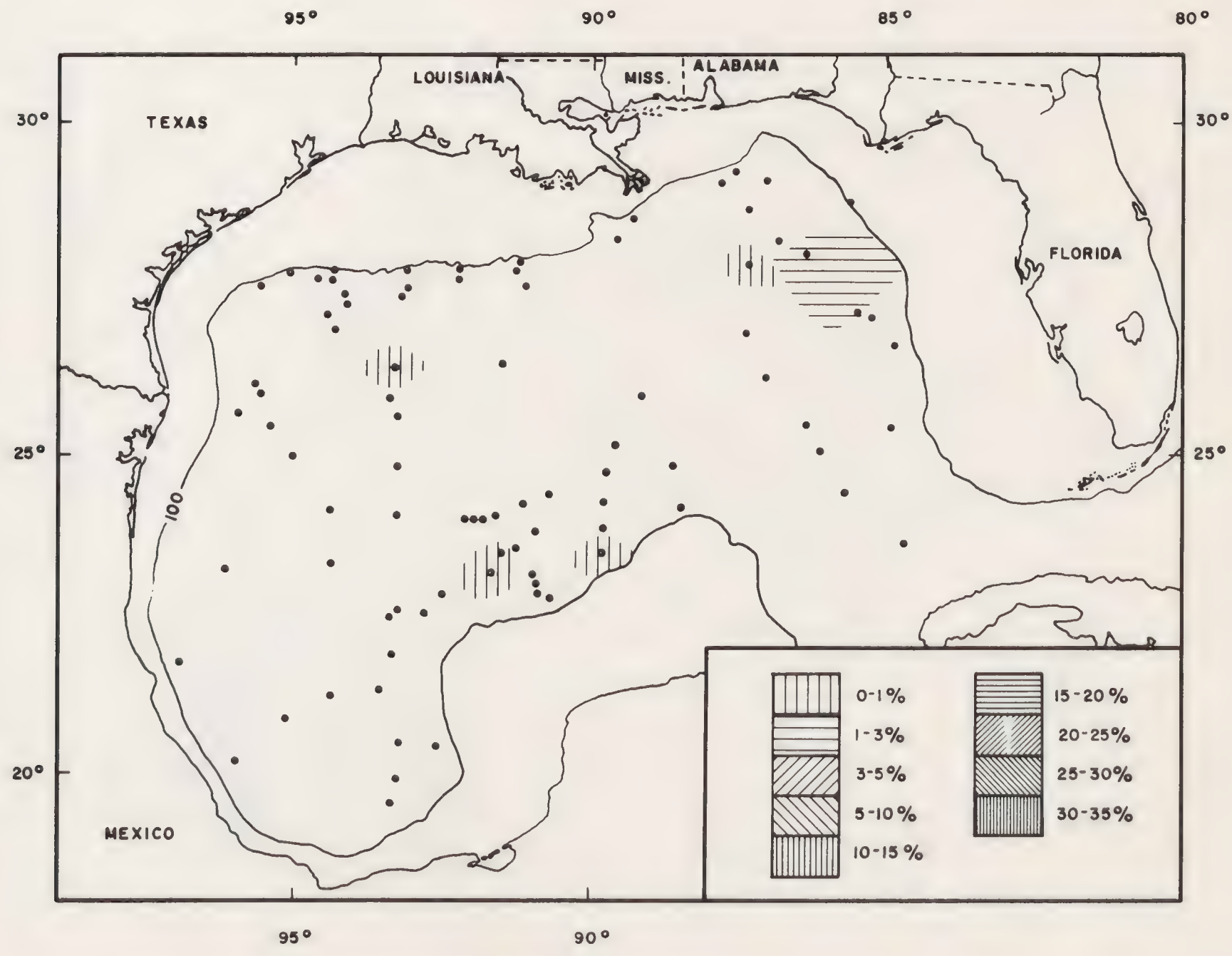

Figure 38. Relative abundance of *Globorotalia flexuosa.*

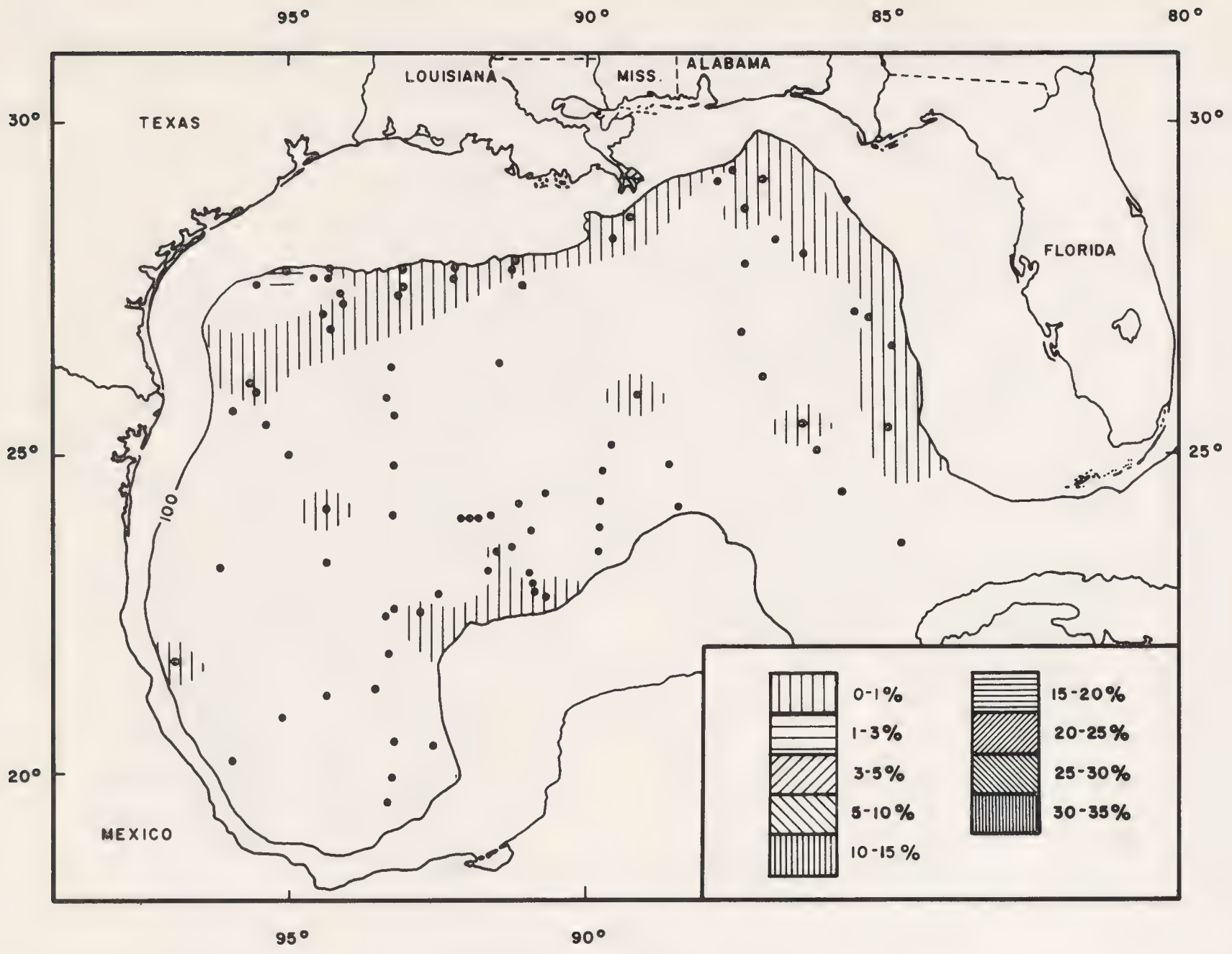

Figure 39. Relative abundance of *Globorotalia hirsuta.*

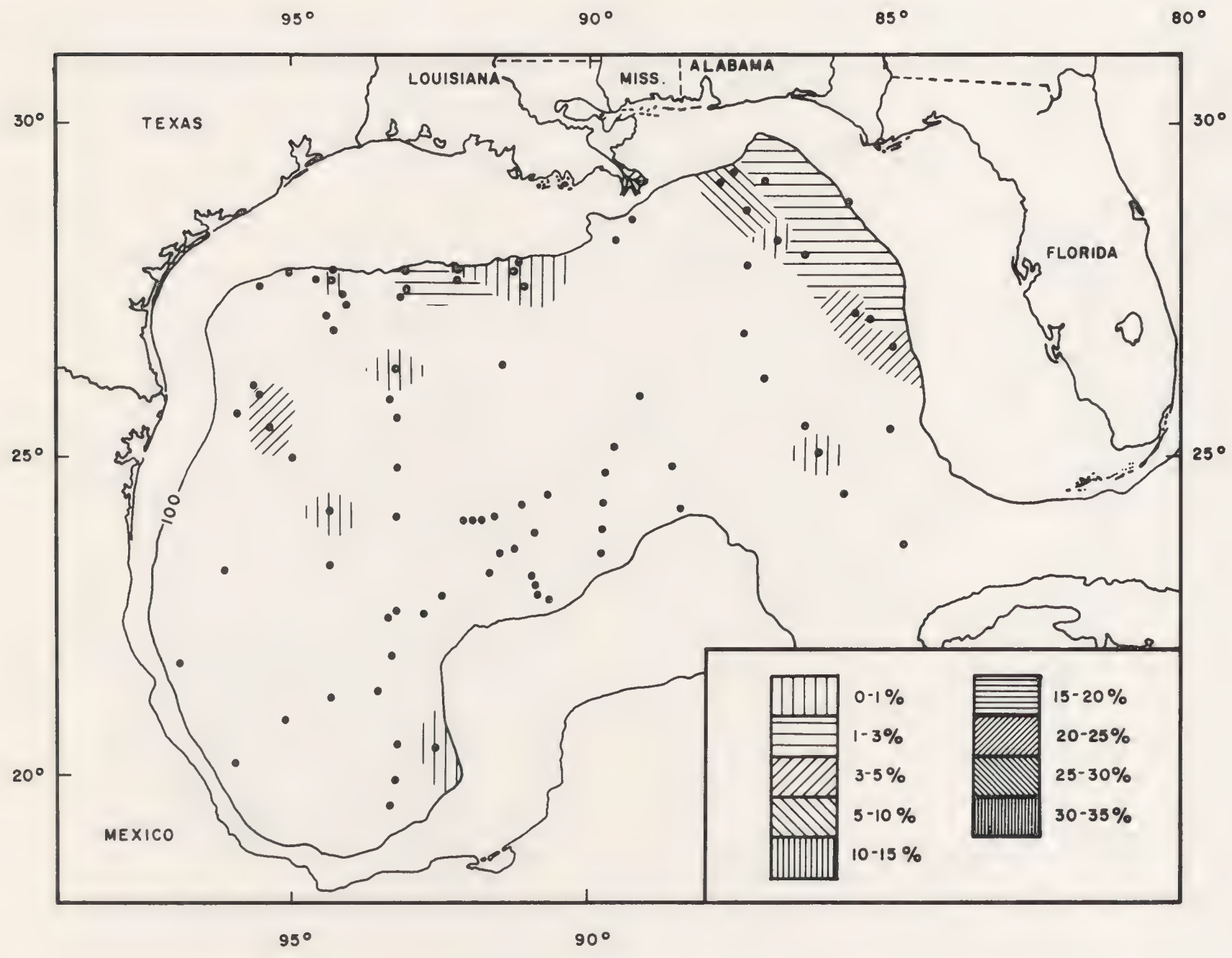

Figure 40. Relative abundance of *Globorotalia inflata.*

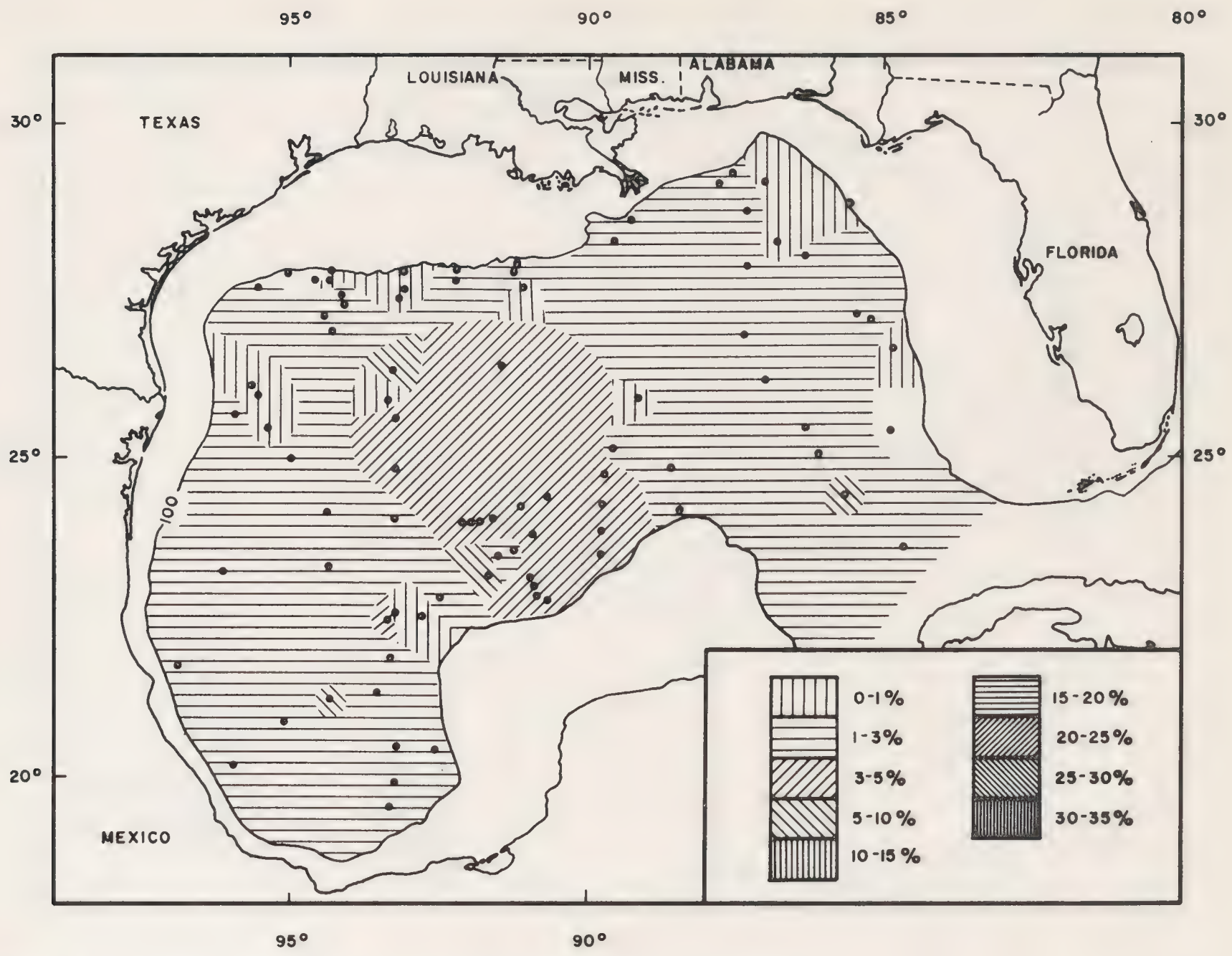

Figure 41. Relative abundance of *Globorotalia menardii.*

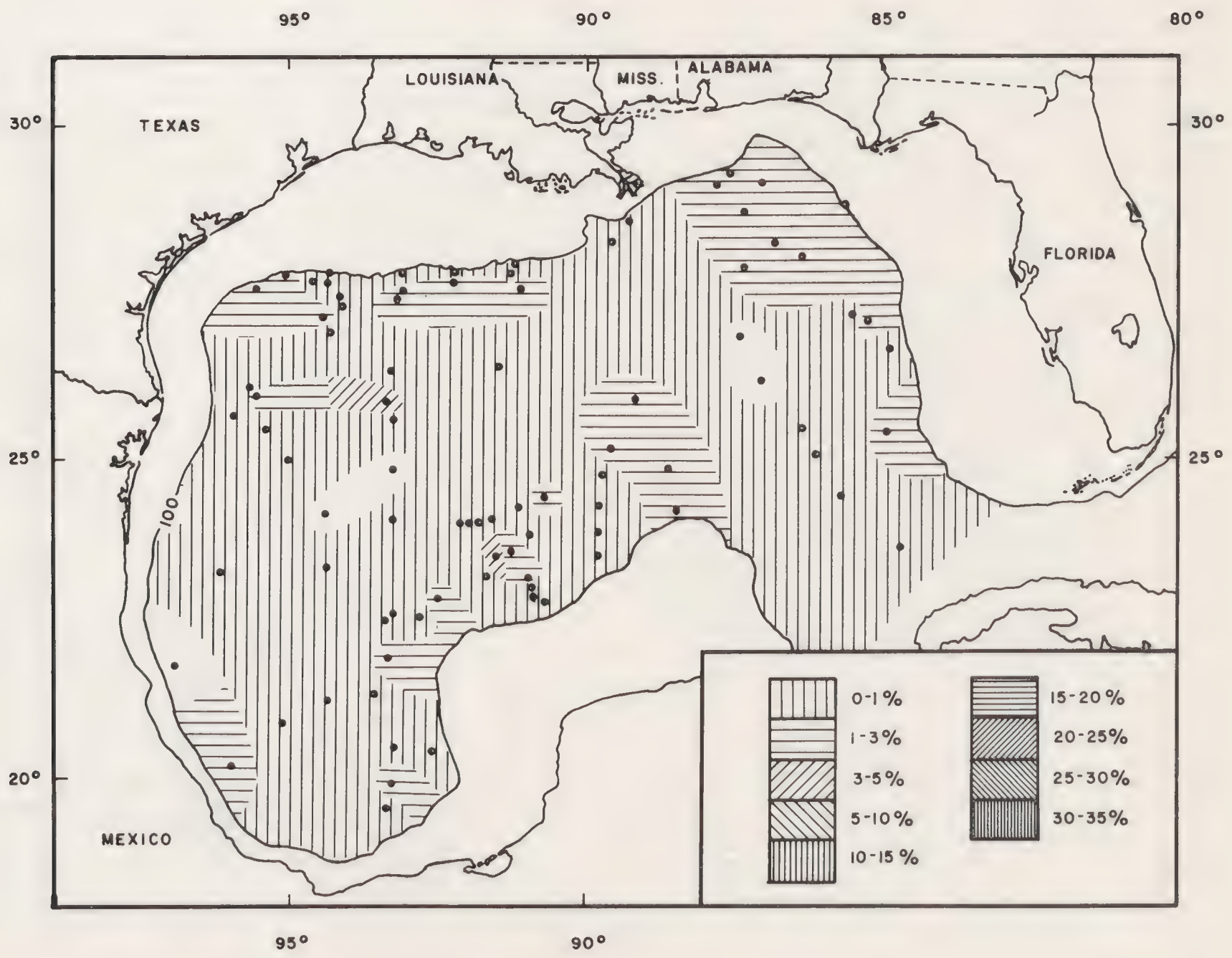

Figure 42. Relative abundance of *Globorotalia scitula.*

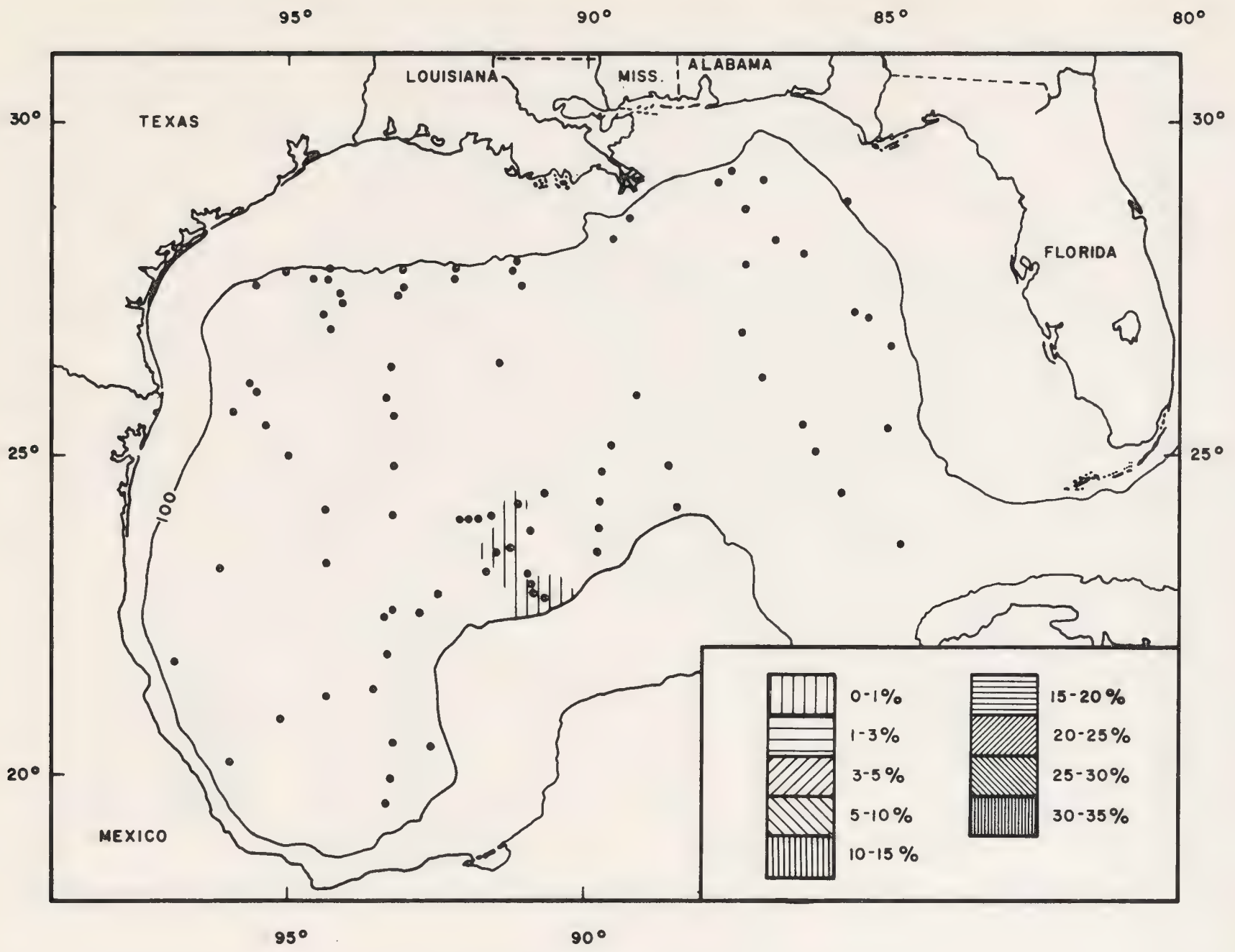

Figure 43. Relative abundance of *Globorotalia akersi.*

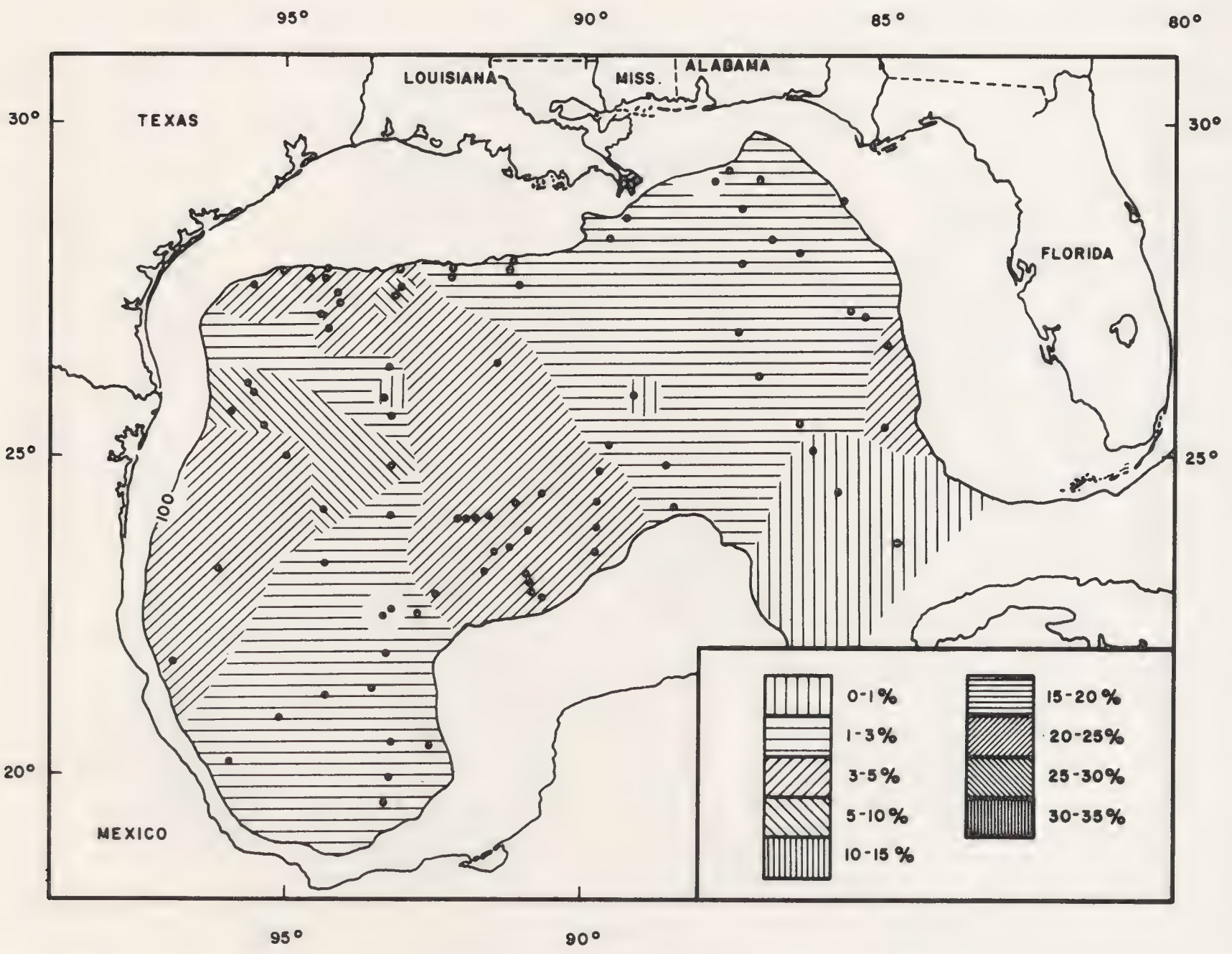

Figure 44. Relative abundance of *Globorotalia truncatulinoides.*

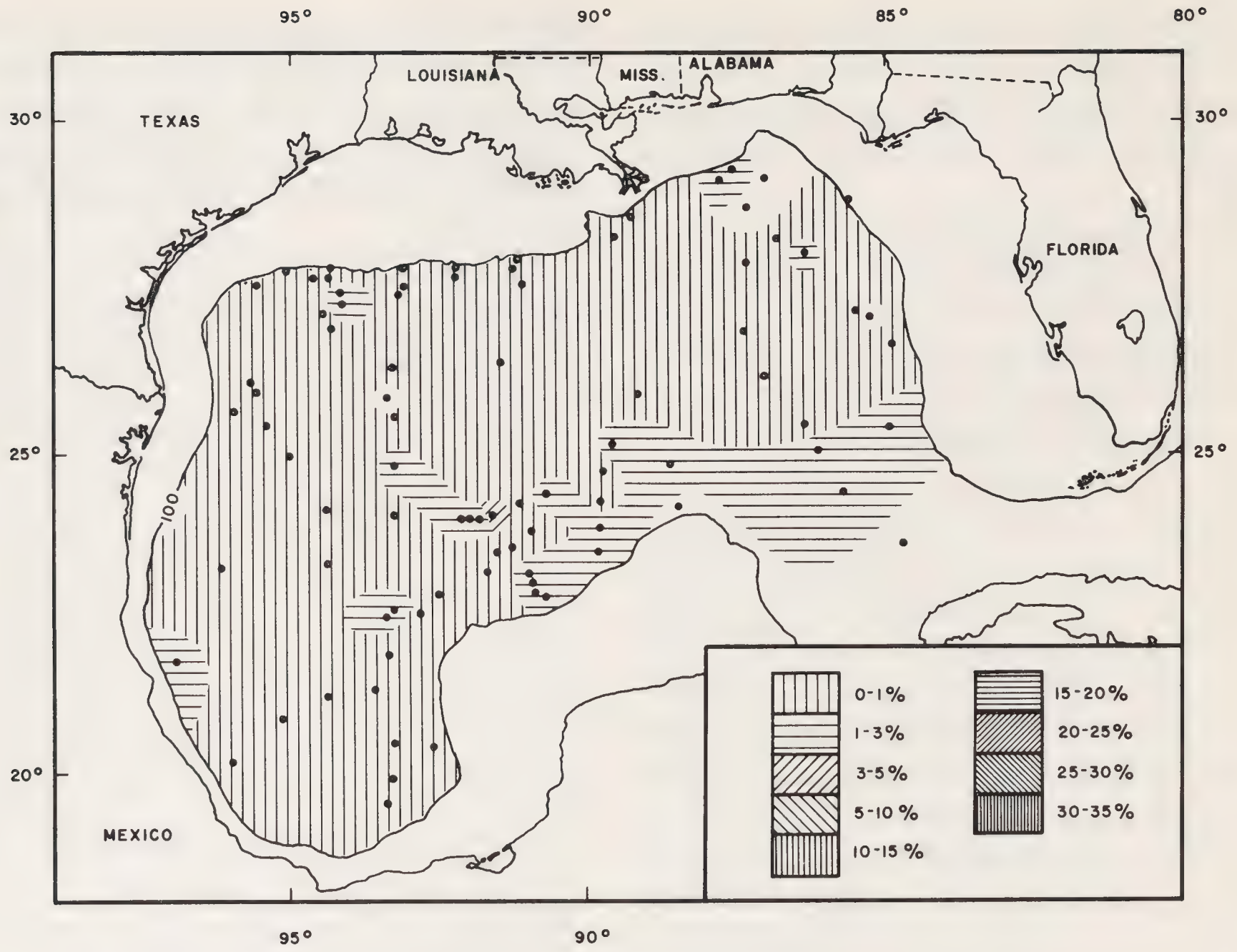

Figure 45. Relative abundance of *Globorotalia tumida.*

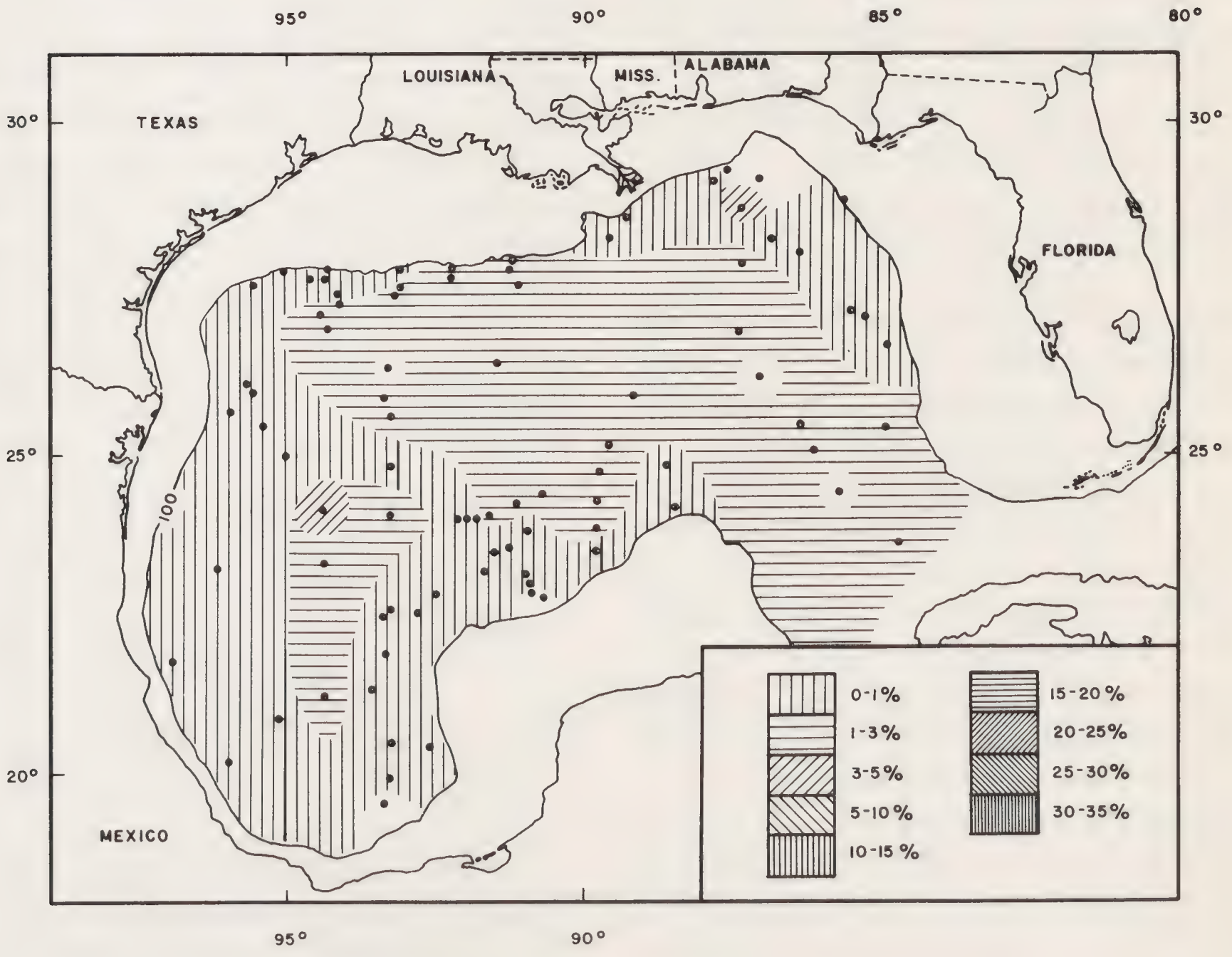

Figure 46. Relative abundance of *Globorotalia ungulata.*

Texas, Louisiana and Mississippi. Also, in a well defined tongue-shaped area extending eastward into the Gulf at approximately 26°N latitude, the relative abundances are 3 to 5%.

The living representatives of this species thrive in water temperatures of 10 to 14°C, depths from the surface to 250 meters, and salinities between 34 and 36 ‰ (fig. 2). Its distributional pattern in the Gulf of Mexico shows a moderate correlation with the distribution of near-surface water temperature values (figs. 3 and 4). Relative abundances greater than 3% are concentrated in areas where the winter temperatures are below 20°C. The tongue-shaped area described above is probably the result of surface currents crossing the areas of high relative abundance of *Globigerina bulloides* from east to west (fig. 6). After being diverted southward, this east to west current system encounters a northward flowing current coming from the Bay of Campeche. The net result is diversion of both currents toward the southeast at a point coincident with the tongue-shaped area of high relative frequencies. The lowest concentrations occur where winter temperatures remain above 23°C.

GLOBIGERINA CALIDA Parker
Plate 2, figures 1-13

Globigerina calida PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 221, pl. 1, figs. 9-13, 15.

Adult specimens are readily separable from those of other species. The major problem is distinguishing the immature specimens of this species from the young of *Globigerinella siphonifera.* Those features used by Parker (1962, p. 222) to separate these two species are applicable to the Gulf of Mexico material. The chambers of young, trochoid *Globigerinella siphonifera* are more involute and the walls are more densely hispid. The latter feature is the most prominent and is more consistently useful.

Globigerina calida comprises less than 1% of the planktonic foraminiferal fauna over nearly its entire area of occurrence within the Gulf of Mexico (fig. 12). It is consistently present only in the surface sediments of the southern part of the area with occurrences in the northern part few in number and widely scattered. There are several isolated patches where relative abundances exceed 1% in the southern portion of its distribution.

No information is available about the ecological optima of living representatives of this species. However, its distribution in Pacific sediments indicates that it is maximally developed in subtropical areas.

In the Gulf of Mexico its presence is limited to an area where the winter temperature of surface waters remains above 22°C (fig. 3). Summer temperatures would presumably offer no restrictions. It is consistently present only in those areas where the surface water salinity values remain above 36 ‰ during the entire year (fig. 5).

GLOBIGERINA DIGITATA Brady
Plate 1, figures 7-12

Globigerina digitata BRADY, 1879, Quart. Jour. Micro. Sci., (new ser.) vol. 19, p. 286.

Globigerina digitata has a distributional pattern very similar to that of *Globigerina calida* (fig. 13). It is consistently represented in surface sediments only in the southern portion of the Gulf of Mexico. Throughout most of the area it constitutes less than 1% of the planktonic foraminiferal assemblage, but several isolated patches with relative abundances greater than 1% are present in the southern Gulf.

Living specimens of *Globigerina digitata* are found only in the tropical latitudes. Its distribution in surface sediments of the Gulf of Mexico is limited to an area where temperatures remain above 22°C (fig. 3), and where surface water salinity values are always above 36 ‰ (fig. 5).

GLOBIGERINA FALCONENSIS Blow
Plate 3, figures 1-6

Globigerina falconensis BLOW, 1959, Bull. Amer. Paleontology, vol. 39, no. 178, p. 177, pl. 9, figs. 40-41.

The apparent intergradation of this form with *Globigerina bulloides* has been discussed under that species. There may also be a problem in distinguishing some specimens

of *Globigerina falconensis* from *Globigerinita glutinata.* The smoother test surface, extraumbilical position of the aperture, and lack of an apertural lip in *Globigerinita glutinata* serve as distinguishing features.

Globigerina falconensis comprises 1 to 3% of the planktonic foraminiferal assemblage in surface sediments throughout most of the Gulf of Mexico (fig. 14). Scattered, isolated patches where the concentration is below 1% occur primarily in the southern part of the region. Concentrations ranging between 5 and 10% are present along the continental slope off Texas and Louisiana. Relative abundances of 3 to 5% occur most commonly in the northern portions, but isolated areas within this range of percentages occur in the western and central Gulf.

The optimum temperature and salinity ranges for living representatives of this species are similar to those of *Globigerina bulloides.* It thrives under conditions only slightly warmer than those that are optimum for the latter species.

High relative abundances of *Globigerina falconensis* (fig. 14) correspond to the area in which winter temperatures at the surface of the overlying water mass are below 20°C (fig. 3). Surface current systems modify this pattern in one isolated area, near 26°N latitude, where high relative abundances (those above 3%) occur. This area is elongated to the east and owes its existence to the current system described under *Globigerina bulloides.*

A variant of *Globigerina falconensis* with a reduced final chamber has high relative abundances (fig. 15) in the area in which winter and spring temperatures at a depth of 100 meters are below 20°C (fig. 4). A prominent zone with relative abundances below 3%, and extending from the southeastern extremity of the study area to the continental slope off western Louisiana, results from warmer water introduced by surface currents (fig. 6).

Both forms of this species are moderately susceptible to solution. However, effects are recognizable only at those stations characterized by high amounts of solution.

GLOBIGERINA PACHYDERMA (Ehrenberg)

Plate 4, figures 1-5

Aristerospira pachyderma EHRENBERG, 1861, K. Preuss. Akad. Wiss. Berlin, Monatsber., pp. 276, 277, 303.

The chambering makes this species easily distinguishable from other species of the genus, except for some particularly robust specimens of *Globigerina quinqueloba.* However, the surface texture of the latter species is much less densely and less coarsely hispid.

Globigerina pachyderma, except for a few widely scattered and rare occurrences in the southern Gulf of Mexico, is found only in the northern part of this region where it generally constitutes less than 1% of the planktonic foraminiferal fauna (fig. 16). Only in an area of the western Gulf, at approximately 26°N latitude, and an area along the continental slope off Alabama and Florida do relative abundances exceed 1%.

Only dextral specimens of *Globigerina pachyderma* are present in surface sediments of the Gulf of Mexico. Although they tolerate a wide range of temperatures, the optimum range of dextral forms is 11 to 15°C. The optimum salinity and depth ranges are 34.5 to 35 ‰ and 0 to 300 meters, respectively (fig. 2).

Distributional patterns in surface sediments can be correlated with the distribution of surface water temperature and salinity values. The species is present only where surface water temperatures are less than 19°C during winter (fig. 3). In this area, water temperature at a depth of 100 meters remains below 19°C during the entire year, and salinity values range only from 34 to 35 ‰ (figs. 4 and 5).

GLOBIGERINA QUINQUELOBA Natland

Plate 4, figures 6-12

Globigerina quinqueloba NATLAND, 1938, Calif. Univ., Scripps Inst. Oceanography, Tech. Ser., vol. 4, no. 5, p. 149, pl. 6, fig. 7.

Although the specimens of *Globigerina quinqueloba* from the Gulf of Mexico may not represent the most common phenon within the species (Parker, 1962, p. 225;

Boltovskoy, 1969, p. 250), it is distinct from other species within the study area. The less densely hispid test serves to distinguish it from *Globigerina pachyderma,* a species with which it may be confused in materials collected from higher latitudes.

Globigerina quinqueloba constitutes 5 to 10% of the planktonic foraminiferal assemblage in surface sediments throughout most of the Gulf of Mexico (fig. 17). In a large region in the south-central portion of the Gulf concentrations range from less than 1% up to 5%. In a few isolated areas (at or near the edge of the continental slope) off Florida, Louisiana, Texas, and Yucatan the relative abundance of this species reaches 10 to 15% of the total assemblage. In two areas along the upper continental slope, directly opposite of the Apalachicola and Sabine rivers, concentrations reach 15 to 20%.

Various authors estimate the temperature range within which *Globigerina quinqueloba* flourishes at 12 to 15°C. It thrives in salinities of 34.5 to 35 ‰ and occurs from the surface to a depth of 250 meters (fig. 2). This species lives mostly in cold-temperate waters, but occurs over a wide range of latitudes.

The distributional pattern of *Globigerina quinqueloba* does not correspond with the distribution of temperature and salinity values in surface waters of the Gulf of Mexico. Relative abundances of 15 to 20% occur in areas where water temperatures at a depth of 100 meters are below 20°C during most of the year (fig. 4). However, concentrations of 5 to 10% are present in areas where temperatures at this depth are quite variable.

Areas with low relative abundances may be largely the product of surface current systems (fig. 6). These areas have little circulation, and it may be that *Globigerina quinqueloba* is more severely limited by lack of circulation than by temperature requirements.

GLOBIGERINA RUBESCENS Hofker
Plate 4, figures 13-16

Globigerina rubescens HOFKER, 1956, Copenhagen Univ., Zool. Mus., Spolia, vol. 15, p. 234, pl. 35, figs. 18-21.

Globigerina rubescens is easily separated from other species, except for specimens of *Globigerinoides tenellus* in which the secondary aperture at the base of the final chamber is filled with sediment and cannot be discerned. The great similarity in chambering of these species makes determining the presence or absence of the secondary aperture critical. Additional cleaning is often necessary to make accurate species identification. Immature specimens of *Globigerinoides ruber* with four chambers in the peripheral whorl may resemble *Globigerina rubescens,* which has a more restricted aperture, a more finely hispid wall, and more spherical chambers than *Globigerinoides*

PLATE 1

Figures Page

1-6. *Globigerina bulloides* d'Orbigny (X200) 15
1. Umbilical view; Station 55
2. Umbilical view; Station 55
3. Umbilical view; Station 55
4. Umbilical view; Station 53
5. Spiral view; Station 53
6. Umbilical view; Station 24
7-12. *Globigerina digitata* Brady (X100) 34
7. Umbilical view; Station 46
8. Spiral view; Station 46
9. Edge view; Station 46
10. Umbilical view; Station 46
11. Umbilical view; Station 46
12. Oblique view; Station 46

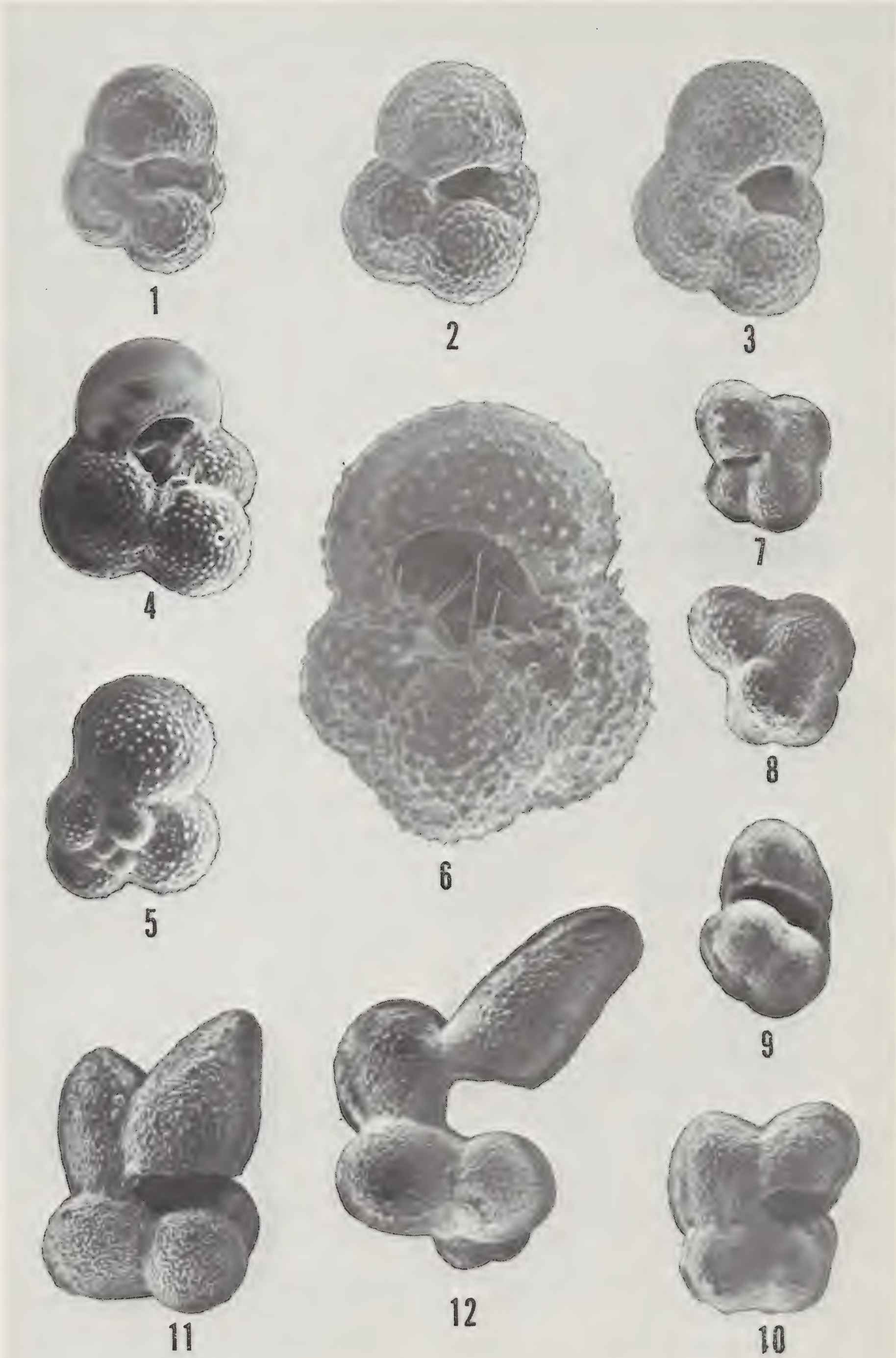

PLATE 1

ruber. The nearly diamond-shaped outline of *Globigerina rubescens* is useful in separating these two species.

Globigerina rubescens constitutes 5 to 10% of the planktonic foraminiferal assemblage throughout nearly the entire study area (fig. 18). In only a few isolated patches is the relative abundance below 5%. These patches are located along the continental slope in the northern Gulf of Mexico and in its west-central portions. Restricted areas with concentrations between 10 and 15% occur in the extreme southwestern and in the northwestern parts of the study area.

The distribution of this tropical-subtropical species does not correspond to the distribution of temperature and salinity values in surface and near-surface waters. Concentrations between 5 and 10% occur across all values of these parameters.

Globigerina rubescens has very little resistance to solution (table 1). The isolated areas with very low relative abundances may be caused by solution.

GLOBIGERINA sp.
Plate 3, figs. 7-8

Globigerina sp. may represent the immature stage of another form in the fauna; but it cannot be related to any of the other identified species by this writer.

This form occurs primarily in the central Gulf of Mexico (fig. 19). It usually constitutes less than 1% of the planktonic foraminiferal assemblage in surface sediments. In several isolated localities it comprises from 1 to 2% and, conversely, it is absent from sediments throughout much of the north-central, northeastern, and southwestern portions of the study area.

Genus GLOBIGERINELLA Cushman, 1927

GLOBIGERINELLA SIPHONIFERA (d'Orbigny)
Plate 5, figures 1-15

Globigerina siphonifera D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, p. 83, pl. 4, figs. 15-18.

It is difficult to distinguish immature specimens of this species from immature *Globigerina calida*, which has less involute chambers and a less hispid wall. The more coarsely hispid surface of *Globigerinella siphonifera* is the most useful criterion for very small specimens.

Globigerinella siphonifera constitutes 5 to 10% of the planktonic foraminiferal assemblage in surface sediments throughout most of the study area (fig. 20). Relative abundances between 3 and 5% are also present over a large area. The relative abundance of this species drops below 1% only at stations located in the most northern extremities of the study area. Areas where it constitutes less than 3% of the fauna are found only on the continental slope in the northern Gulf.

PLATE 2

Figures Page

1-13. *Globigerina calida* Parker (X100) 34
1. Umbilical view; Station 46
2. Spiral view; Station 46
3. Spiral view; Station 46
4. Umbilical view; Station 46
5. Edge view; Station 46; dissected from adult specimen
6. Umbilical view; Station 46; dissected from adult specimen
7. Umbilical view; Station 46
8. Spiral view; Station 46; dissected from adult specimen
9. Spiral view; Station 46
10. Umbilical view; Station 46
11. Spiral view; Station 46
12. Umbilical view; Station 46
13. Edge view; Station 46

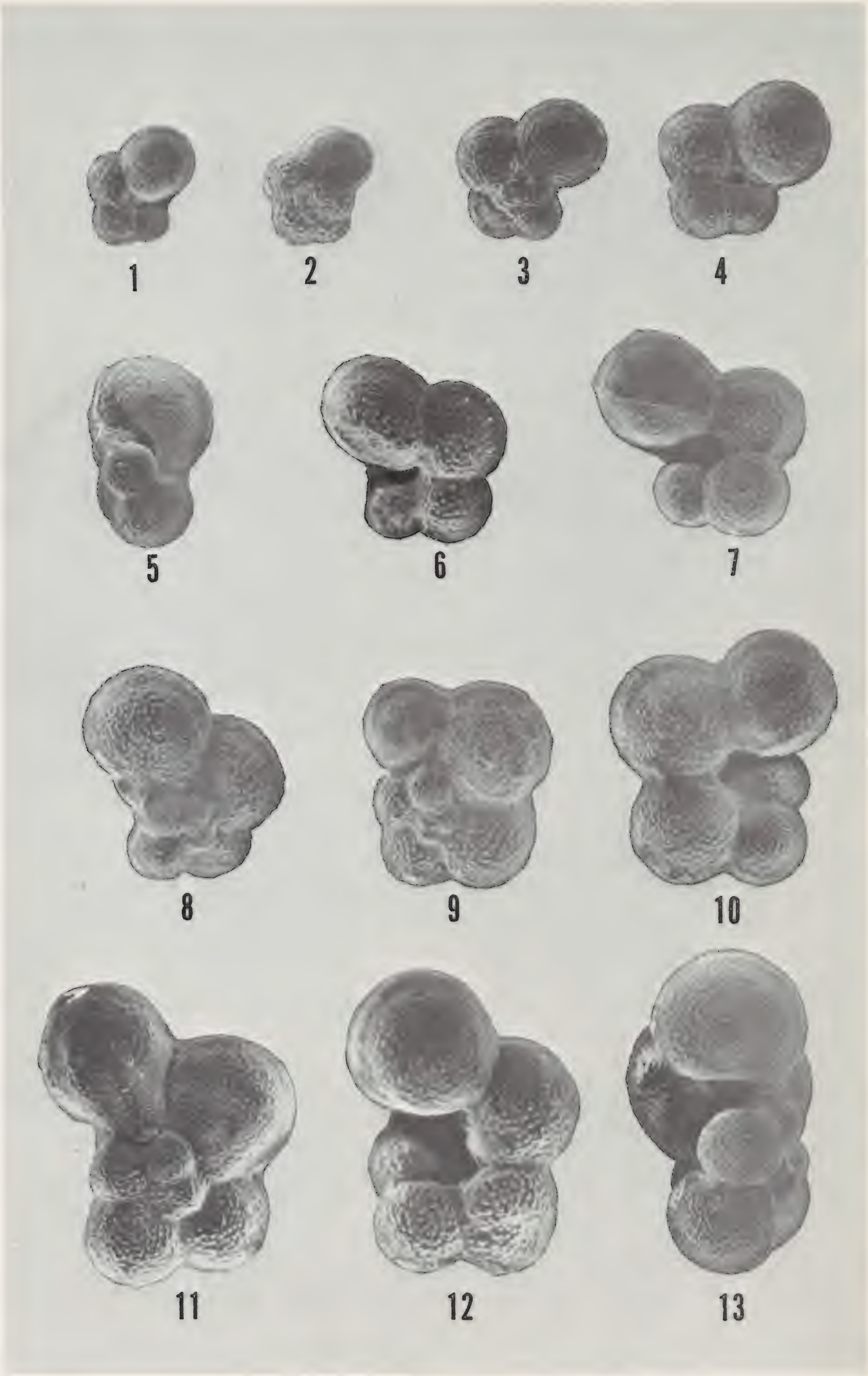

PLATE 2

Concentrations of 5 to 10% are present throughout the most southern regions of the study area. The pattern of this particular range of abundances extends north-northwest in two areas, one from both the eastern and western limits of the Campeche Slope. Relative abundances between 3 and 5% are found mainly in the western and north-central Gulf of Mexico.

This subtropical-tropical species tolerates a broad range of temperatures but flourishes only where temperatures exceed 20°C. Optimum ecological conditions also include salinities above 36 ‰ (fig. 2).

Concentrations above 3% of the assemblage are found only in an area approximating that defined by year-round near-surface (at a depth of 100 meters) water temperatures above 20°C. The configuration of temperature contours at this depth during late winter and late summer (fig. 4) help explain the aforementioned northward extensions of concentrations between 5 and 10%. It may be that this species is most abundant at about 100 meters below the surface.

Genus GLOBIGERINOIDES Cushman, 1927

GLOBIGERINOIDES CONGLOBATUS
(Brady)
Plate 6, figures 1-4

Globigerina conglobata BRADY, 1879, Quart. Jour. Micr. Sci., (new ser.) vol. 19, p. 286.

Globigerinoides conglobatus comprises less than 1% of the planktonic foraminiferal assemblage in surface sediments throughout most of the Gulf of Mexico, with the exception of an area that corresponds to the Mississippi Cone (fig. 21). It comprises 1 to 2% of the fauna only in an area that trends northwest from the Campeche Slope to the continental slope off east-central Texas.

This tropical-subtropical species flourishes in temperatures above 21°C and salinities above 36 ‰ (fig. 2). However, its absence in the area of the Mississippi Cone indicates that turbidity may be the single most important factor limiting its distribution in this area.

GLOBIGERINOIDES ELONGATUS
(d'Orbigny)
Plate 7, figures 1-7

Globigerina elongata D'ORBIGNY, 1826, Ann. Sci. Nat., (ser. 1) vol. 7, p. 277 (unfigured).

"*Globigerinoides elongatus* closely resembles and possibly is a variant form of *G. ruber*" (Cifelli and Smith, 1970, p. 37). It differs from *Globigerinoides ruber* sensu stricto in that the chambers are slightly less inflated, the final chamber is compressed and relatively small, and the primary aperture is more laterally restricted. Several other distinguishing characters are listed by Banner and Blow (1960, p. 21). However, differences in wall thickness and coarseness do not appear to be applicable to specimens representing these two species in the Gulf of Mexico.

Globigerinoides elongatus constitutes 1 to 3% of the planktonic foraminiferal assemblage in surface sediments throughout most of the Gulf of Mexico (fig. 22). Scattered areas with relative abundances below 1%

PLATE 3

Figures — Page

1-6. *Globigerina falconensis* Blow (X200) 34
1. Umbilical view; Station 53
2. Spiral view; Station 47
3. Umbilical view; Station 43
4. Umbilical view; Station 53
5. Umbilical view; Station 36; morphologic variant with reduced final chamber
6. Spiral view; Station 41; morphologic variant with reduced final chamber

7-8. *Globigerina* sp. (X200) 38
7. Umbilical view; Station 72
8. Spiral view; Station 72

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PLATE 3

occur near the northern, western, and south-central limits of the study area, and small areas with concentrations of 3 to 5% and 5 to 10% are present only in the south and central portions.

Cifelli and Smith (1970, p. 37) state that the distribution of this subtropical species in Atlantic populations is similar to but more restricted than that of *Globigerinoides ruber.* In the Gulf of Mexico its higher relative abundances occur where year-round water temperatures at a depth of 100 meters are above 20°C; but these scattered, isolated concentrations make it difficult to evaluate the importance of temperature as a limiting factor.

GLOBIGERINOIDES FISTULOSUS (Schubert)
Plate 6, figure 5

Globigerina fistulosa SCHUBERT, 1910, Geol. Reichsanst. Verh., Vienna, p. 323, fig. 2.

In the Indo-Pacific region *Globigerinoides fistulosus* becomes extinct in the early Quaternary. Lamb and Beard (1972, p. 48) state that this species is encountered only in the late Pliocene and earliest Pleistocene in the Gulf of Mexico. Ericson and Wollin (1968, p. 1232) recognize its extinction level within the early Pleistocene. Its presence in surface sediments indicates either that pre-Pleistocene sediments are exposed or that there has been vertical mixing during sampling. At both stations where *Globigerinoides fistulosus* occurs, its presence is attributed to vertical mixing.

GLOBIGERINOIDES OBLIQUUS OBLIQUUS Bolli

Globigerinoides obliqua BOLLI, 1957, U. S. Natl. Mus., Bull. 215, p. 113, pl. 25, figs. 9-10; text-fig. 21, no. 5.

Some specimens here included within the concept of *Globigerinoides elongatus* (pl. 7, fig. 5) closely resemble *Globigerinoides obliquus obliquus.* Bronnimann and Resig (1971, p. 1310) place *Globigerinoides obliquus obliquus* in synonymy with *Globigerinoides elongatus.* However, in the opinion of this writer these two species are separate.

Parker (1967, p. 155) states that *Globigerinoides obliquus obliquus* ranges into zone N. 21 (latest Pliocene) in Indo-Pacific cores. Blow (1969, p. 268) lists the range as extending into zone N. 22 (early Pleistocene). Lamb and Beard (1972, p. 48) state that the range extends through the lower

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PLATE 4

Figures — Page

1-5. *Globigerina pachyderma* (Ehrenberg) (X150) 35
1. Umbilical view; Station 41
2. Umbilical view; Station 31
3. Spiral view; Station 1
4. Umbilical view; Station 32
5. Umbilical view; Station 28
6-12. *Globigerina quinqueloba* Natland (X200) 35
6. Umbilical view; Station 53
7. Umbilical view; Station 52
8. Umbilical view; Station 52
9. Spiral view; Station 52
10. Umbilical view; Station 52
11. Edge view; Station 52
12. Umbilical view; Station 70
13-16. *Globigerina rubescens* Hofker 36
13. Umbilical view, X 200; Station78
14. Umbilical view, X 300; Station 46
15. Spiral view, X 300; Station 46
16. Umbilical view, X 200; Station 78

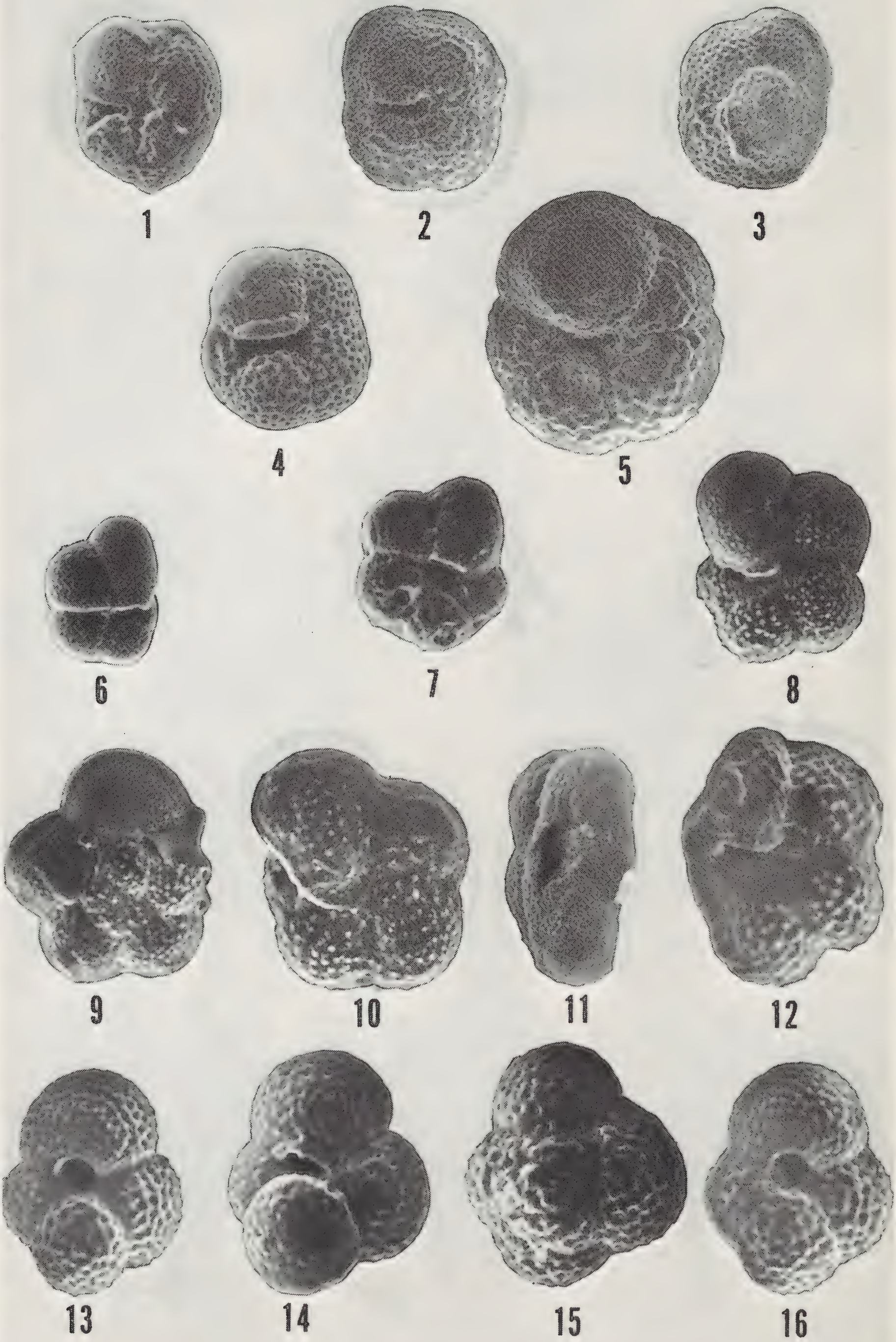

PLATE 4

Pleistocene sediments in the Gulf of Mexico. Boltovskoy and Watanabe (1975, p. 40) recognize this species in Recent assemblages from sediments of the South Pacific Ocean.

Specimens of *Globigerinoides obliquus obliquus* occur only at Station 1. Because its representatives constitute less than 1% of the planktonic foraminiferal fauna, and because there is no other faunal evidence to suggest exposure of pre-Holocene sediments, its presence is interpreted as indicating vertical mixing.

GLOBIGERINOIDES QUADRILOBATUS QUADRILOBATUS (d'Orbigny)

Plate 8, figures 1-7

Globigerina quadrilobata D'ORBIGNY, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 164, pl. 9, ? figs. 7-10.

While identification of mature specimens presents few difficulties, immature specimens may be confused with several other species, such as *Globigerinoides ruber.* The main distinguishing feature is that the aperture of *Globigerinoides quadrilobatus quadrilobatus* is more slit-like and restricted. Also, there are a greater number of chambers in the very early whorls than in *Globigerinoides ruber.* The growth series figured by Cifelli and Smith (1970, p. 38 and 39) for both of these species are most helpful for illustration of the differences mentioned above. In addition, immature *Globigerinoides quadrilobatus quadrilobatus* is chambered almost identically to some specimens of *Globigerinita glutinata,* causing difficulty if the characteristic umbilical bulla of the latter species is missing (compare pl. 8, fig. 1, with pl. 14, fig. 4). Identification is then made on the basis of the surface texture of *Globigerinoides quadrilobatus quadrilobatus* being much more coarsely cancellate and punctate. The problem of distinguishing *Globigerinoides quadrilobatus quadrilobatus* from *Globigerinoides quadrilobatus sacculifer* is discussed under the latter subspecies.

The relative abundances of *Globigerinoides quadrilobatus quadrilobatus* below 3% occur only in the northern, western, and southwestern portions of the study area (fig. 23). Concentrations from 3 to 5% of the planktonic assemblage are found only in the central Gulf of Mexico; those between 5 and 10%, almost entirely in the east-central and southeastern portions.

This subspecies thrives in water temperatures above 22°C, salinities above 36 ‰, and at depths from the surface to 50 meters (fig. 2). Areas with relative abundances above 3% occur where near-surface waters (at a depth of 100 meters) maintain year-round temperatures above 21°C.

PLATE 5

Figures Page

1-15. *Globigerinella siphonifera* (d'Orbigny) (X100) 38

1. Umbilical view; Station 46
2. Spiral view; Station 46
3. Umbilical view; Station 46
4. Edge view; Station 46
5. Spiral view; Station 46
6. Edge view; Station 46
7. Edge view; Station 46
8. Oblique view; Station 46
9. Edge view; Station 46
10. Edge view; Station 46
11. Edge view; Station 46
12. Edge view; Station 46
13. Umbilical view; Station 72
14. Edge view; Station 72
15. Spiral view; Station 72

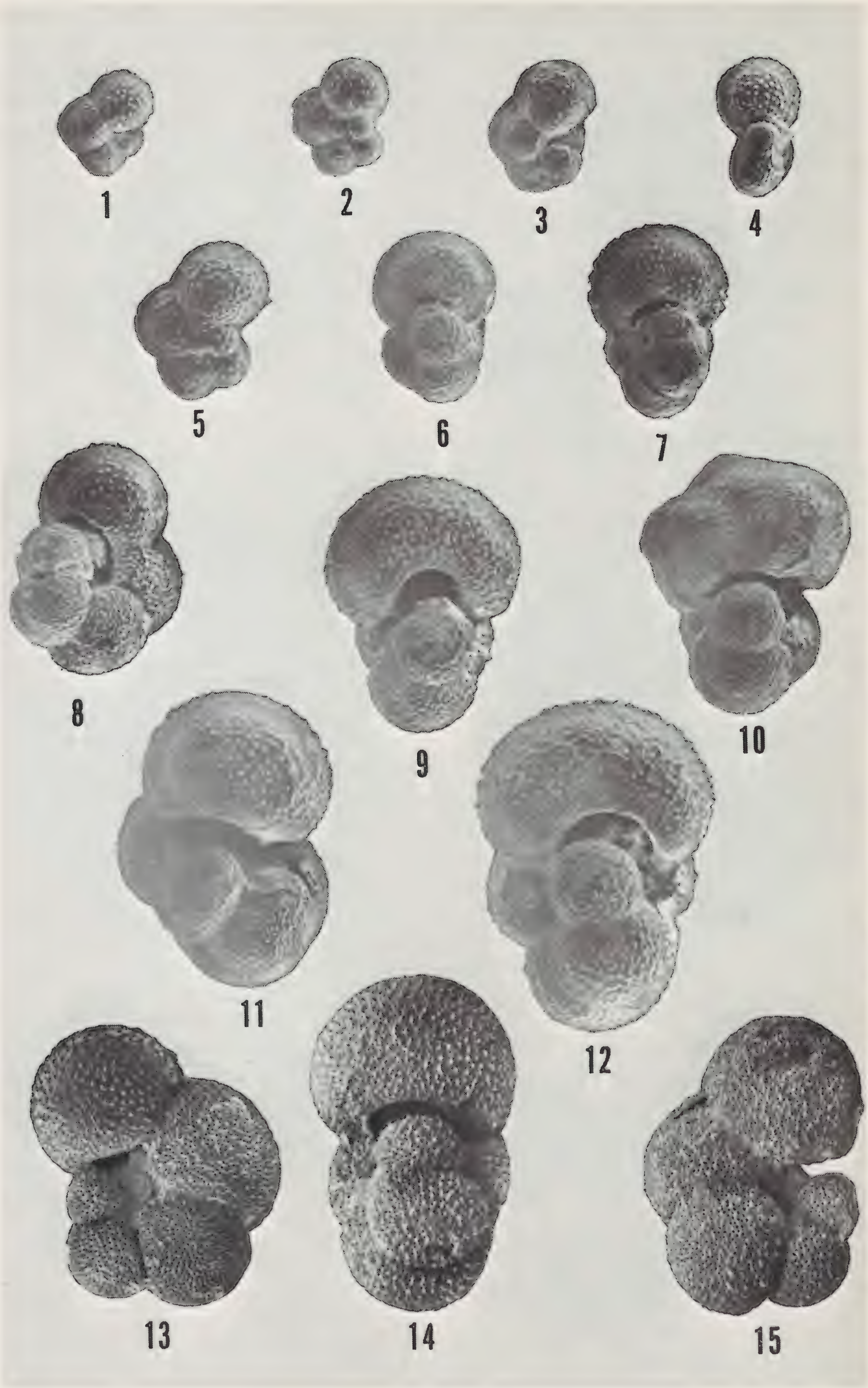

PLATE 5

GLOBIGERINOIDES QUADRILOBATUS SACCULIFER (Brady)
Plate 9, figures 1-7

Globigerina sacculifera BRADY, 1877, Geol. Mag., (new ser., dec. 2) vol. 4, no. 12, p. 535.

Specimens of *Globigerinoides quadrilobatus* with an irregular to sac-like final chamber are separated as the subspecies *Globigerinoides quadrilobatus sacculifer* (compare the figures of plate 9 with those of plate 8). Cifelli (1965, p. 27) combines both of these forms into one subspecies because he interprets them as a gradational series that does not represent an evolutionary sequence in time. Parker (1962, p. 229) also considers these two forms synonymous. Representing the other viewpoint is Jones (1967, p. 496), "...there is considerable evidence to indicate that the two forms of this species have different preferred environmental habitats, although with a wide degree of overlap, and that some fair degree of justification exists in considering them as true biologic subspecies." While treating the two forms as subspecies, this writer agrees with Cifelli (1965, p. 28) that the present arrangement of subspecies must be considered tentative and incomplete.

Globigerinoides quadrilobatus sacculifer constitutes less than 1% of the planktonic foraminiferal assemblage in surface sediments throughout the northwestern Gulf of Mexico and in a small area in its northeastern portion (fig. 24). Throughout most of the study area the relative abundances range between 1 and 3%. In some parts of the southern Gulf there are scattered stations with concentrations from 3 to 5%, representing the maximal development of the subspecies in this region.

Living representatives of this subspecies flourish in temperatures above 23°C, salinities above 36 ‰ , and depths from the surface to 100 meters (fig. 2). Relative concentrations between 3 and 5% occur only where surface water temperatures remain above 23°C during the entire year (fig. 3). The only large area with relative abundances of 3 to 5% is located where year-round water temperatures at a depth of 100 meters are above 21°C. Like the more susceptible species, its distributional patterns may be altered by solution effects, which may explain its absence in certain parts of the area (fig. 24).

GLOBIGERINOIDES RUBER (d'Orbigny)
Plate 10, figures 1-9

Globigerina rubra D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, p. 82.

There is some variation in coiling in immature forms of *Globigerinoides ruber.* Most specimens have three chambers in the peripheral whorl (pl. 10, figs. 1-2, 4-6), however, one form has four (pl. 10, fig. 3). This form resembles a *Globigerina.* Resemblance is enhanced by the fact that supplementary apertures appear late in the ontogeny of *Globigerinoides ruber* and are seldom seen in small specimens. The only way to identify such specimens is to become thoroughly familiar with the growth series of the species (Cifelli and Smith, 1970, p. 38).

Adult specimens are distinctive and easily recognized but some immature forms may be confused with immature forms of *Globigerinoides quadrilobatus.* Distinguishing features are discussed under the latter species.

PLATE 6

Figures Page

1-4. *Globigerinoides conglobatus* (Brady) (X100) 40
1. Umbilical view; Station 46
2. Spiral view; Station 46
3. Umbilical view; Station 46
4. Spiral view; Station 46
5. *Globigerinoides fistulosus* (Schubert) (X77) 42
Spiral view; Station 46

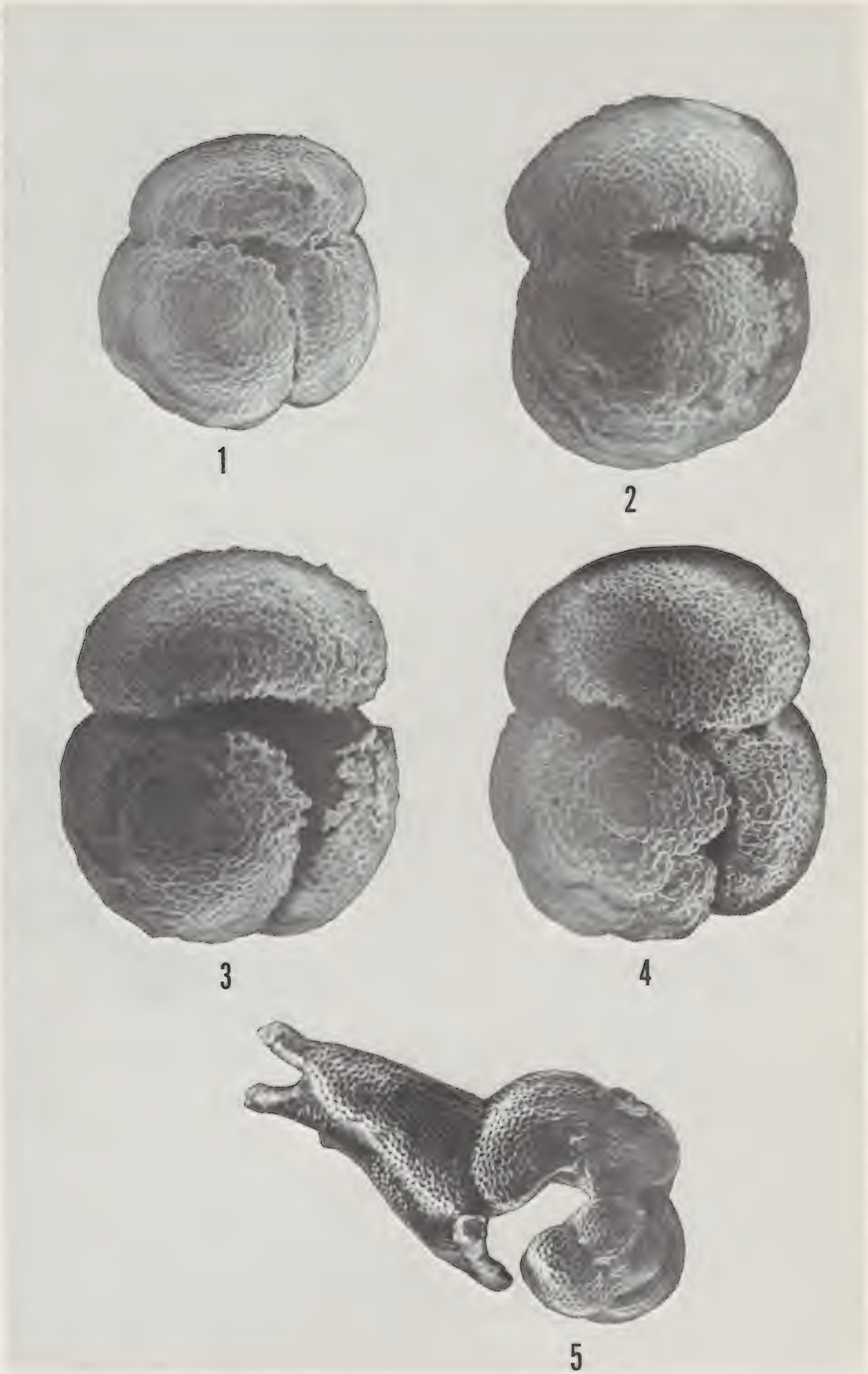

PLATE 6

Globigerinoides ruber is the most abundant planktonic foraminiferal species in surface sediments of the Gulf of Mexico (fig. 25). Over most of the area it constitutes 25% or more of the planktonic foraminiferal assemblage. Only the shoaler, most northern regions have relative abundances less than 25%; and, even here the relative abundance exceeds 10%. In the area of maximum development of the species, the south-central to central-western portion of the Gulf, relative abundances range between 30 and 35%.

Although *Globigerinoides ruber* has broad ecological tolerances, living specimens thrive in temperatures above 20°C and salinities above 35.5 ‰ . It is most abundant in the upper 50 meters of the water column but lives throughout the upper 250 meters (fig. 2).

Globigerinoides ruber constitutes 25% or more of the planktonic foraminiferal assemblage in areas where year-round surface water temperatures are above 22°C; and those at a depth of 100 meters, above 20°C (figs. 3 and 4). Concentrations of 30 to 35% occur only where winter temperatures of surface water are above 23°C. Because this species is most susceptible to solution, its relative abundances may be altered (table 1).

GLOBIGERINOIDES TENELLUS
Parker
Plate 7, figures 8-10

Globigerinoides tenellus PARKER, 1958, Swedish Deep-Sea Exped., Rept., vol. 8, no. 4, p. 280, pl. 6, figs. 7-11.

Globigerinoides tenellus may be confused with specimens of *Globigerina rubescens* that lack pigmentation. The presence of the supplementary aperture (pl. 7, fig. 8) serves to distinguish the two, but this aperture may be difficult to see without tedious, time-consuming manual cleaning. Great care must be exercised in determining whether or not it is present. The slightly extraumbilical position of the primary aperture in most specimens of *Globigerinoides tenellus* (pl. 7, fig. 10) may aid in distinguishing it from *Globigerina rubescens.* However, the extent to which its position is extraumbilical varies and some specimens have a primary aperture that is nearly umbilical (pl. 7, fig. 9).

Globigerinoides tenellus constitutes 1 to 3% of the planktonic foraminiferal fauna in surface sediments throughout most of the study area (fig. 26). Concentrations below 1% occur along the continental slope off Texas, Louisiana, Alabama, and Florida. An area with relative abundances ranging from 3 to 10% trends northwest from the Bay of Campeche into the central Gulf of Mexico.

Globigerinoides tenellus is considered a poor indicator of temperature values because specimens are quantitatively too few in virtually every latitudinal area. The species' distribution in surface sediments of the Gulf of Mexico supports this statement because it bears little resemblance to the distribution of temperature values.

PLATE 7

Figures Page

1-7. *Globigerinoides elongatus* (d'Orbigny) (X100) 40
1. Umbilical view; Station 49
2. Spiral view; Station 46
3. Spiral view; Station 46
4. Spiral view; Station 46
5. Umbilical view; Station 46
6. Spiral view; Station 48
7. Umbilical view; Station 46
8-10. *Globigerinoides tenellus* Parker (X200) 48
8. Spiral view; Station 46
9. Umbilical view; Station 46
10. Umbilical view; Station 46

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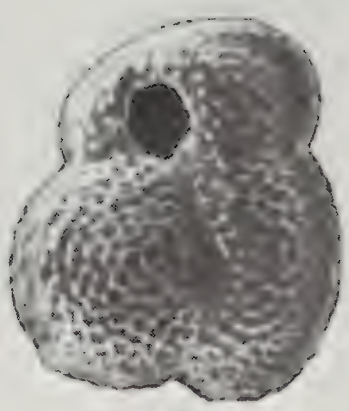

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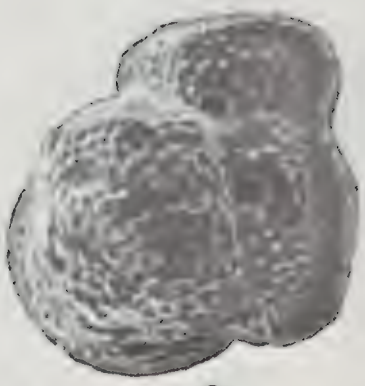

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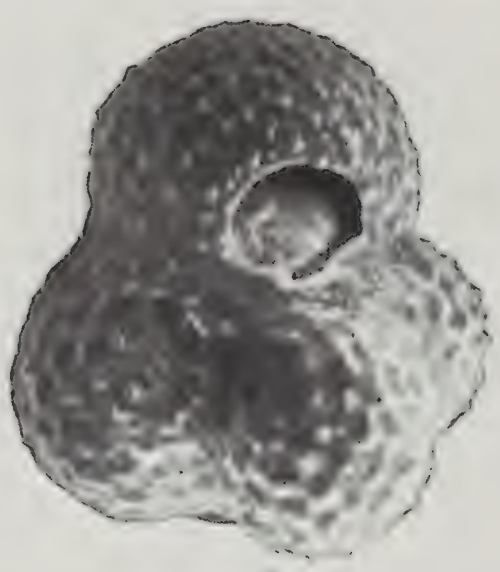

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PLATE 7

Genus ORBULINA d'Orbigny, 1839
ORBULINA BILOBATA (d'Orbigny)
Plate 11, figure 1

Globigerina bilobata D'ORBIGNY, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 164, pl. 9, figs. 11-14.

Orbulina bilobata, which may be a morphologic variant of *Orbulina universa,* ranges into the Holocene but does not become abundant. This species was encountered at three localities in the Gulf of Mexico (fig. 27). In each instance it comprises less than 1% of the planktonic foraminiferal fauna.

ORBULINA SUTURALIS
Bronnimann, *emended* Blow
Plate 11, figure 4

Orbulina suturalis BRONNIMANN, 1951 (part), Cushman Found. Foram. Res., Contr., vol. 2, pt. 4, p. 135, text-fig. 2, nos. 1-2, 5-8, 10; text-fig. 3, nos. 3-8, 11, 13-16, 18, 20-22; text-fig. 4, nos. 2-4, 7-12, 15-16, 19-22.

Orbulina suturalis was originally described from the Oligo-Miocene of Trinidad (Bronnimann, 1951, p. 135). Blow (1956, p. 69), based upon his work in Trinidad, stated that *Orbulina suturalis* became extinct in the late Miocene or early Pliocene. However, this species has been recorded on at least two separate and independent occasions as living in the plankton. Bé and Hamlin (1967, p. 102) describe it as a tropical-subtropical member of the plankton in the North Atlantic where it is present in very small concentrations. Cifelli and Smith (1970, p. 42), also working in the North Atlantic, encountered four living specimens. Hence, the rare occurrence of this species in surface sediments of the Gulf of Mexico does not necessarily indicate either the exposure of earlier Neogene sediments or vertical mixing. This species occurs only at Station 46, where it comprises less than 1% of the planktonic foraminiferal assemblage.

ORBULINA UNIVERSA d'Orbigny
Plate 11, figures 2-3

Orbulina universa D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, vol. 8, no. 3, pl. 1, fig. 1.

Orbulina universa constitutes 1 to 3% of the planktonic foraminiferal fauna throughout most of the Gulf of Mexico (fig. 28). Scattered areas with concentrations below 1% occur along the continental slope in the northern extremities of the study area and in its central and southwestern portions. Relative abundances between 3 and 5% are scattered and isolated.

Orbulina universa is a subtropical species that flourishes in temperatures above 18°C, salinities of 36 ‰ or more, and depths from the surface to 300 meters (fig. 2). Because nearly all seasonal temperatures in the Gulf of Mexico are above 18°C (figs. 3 and 4) this species is widely distributed throughout the area, but with no clear relationship to changes in temperature or salinity.

This species has a very low resistance to solution. Irregularities in its distributional pattern are most likely associated with solution effects.

Genus HASTIGERINA Thompson, 1876
HASTIGERINA PELAGICA (d'Orbigny)
Plate 12, figures 1-2

Nonionina pelagica D'ORBIGNY, 1839, Voyage dans l'Amerique Meridionale, Foraminifères, p. 27, pl. 3, figs. 13-14.

PLATE 8

Figures Page

1-7. *Globigerinoides quadrilobatus quadrilobatus* (d'Orbigny) (X100) 44
1. Umbilical view; Station 46
2. Spiral view; Station 46
3. Umbilical view; Station 72
4. Umbilical view; Station 46
5. Spiral view; Station 46
6. Umbilical view; Station 72
7. Spiral view; Station 72

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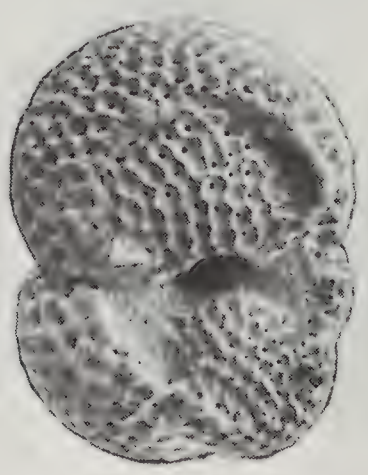

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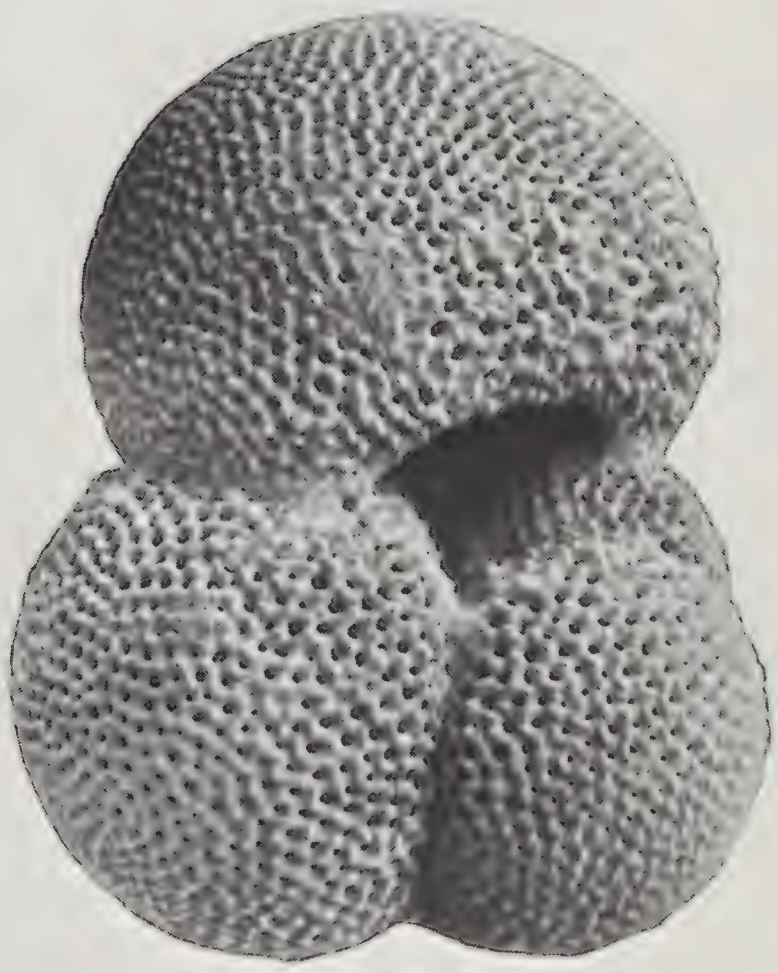

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PLATE 8

The possibility of confusing *Hastigerina pelagica* with other species is remote. Only *Globigerinella siphonifera,* because of its tendency toward planispiral coiling, resembles it. The two can be easily distinguished by differences in the nature of the test surface. That of *Hastigerina pelagica* is finely perforate and bears a relatively few long triradiate spines and the surface of *Globigerinella siphonifera* is densely hispid and bears no triradiate spines.

Hastigerina pelagica occurs primarily in the southwestern portion of the Gulf of Mexico (fig. 29). Here surface sediments consistently yield specimens assignable to this species but the relative abundance at all localities is below 1% of the planktonic foraminiferal fauna. Scattered, isolated occurrences of this species are noted in the central and southeastern portions of the study area.

Hastigerina pelagica thrives in water temperatures above 23°C and salinities above 36 ‰ . Living specimens range to a depth of 1000 meters, but are in greater abundance in the upper 300 meters of the water column (fig. 2).

Hastigerina pelagica occurs only in the area where year-round surface water temperatures are above 22°C (fig. 3). It does not, however, occur consistently throughout this area of warm surface waters, but is found primarily where salinity values remain above 36.25 ‰ (fig. 5). The patchy distribution of this species may be caused by the fragility of the test coupled with its low relative abundance (below 5%) in living populations at the same latitude as the Gulf of Mexico (Bé, Vilks, and Lott, 1971).

Genus PSEUDOHASTIGERINA Banner and Blow, 1959

PSEUDOHASTIGERINA PRAEPUMILIO (Parker)

Plate 12, figures 3-6

Globanomalina praepumilio PARKER, 1967, Bull. Amer. Paleontology, vol. 52, no. 235, p. 148, pl. 18, figs. 1-4.

This form is distinctive but also quite small. The author is unaware of any previous record of its occurrence in the Gulf of Mexico. Parker (1967, p. 148) records a rather restricted range for this species in the Indo-Pacific region where it is found only in the upper part of Zone N. 20 and in N. 21 (late Pliocene).

Pseudohastigerina praepumilio occurs at only two stations in the entire study area. At Station 29 it constitutes less than 1% of the planktonic foraminiferal assemblage. This occurrence is interpreted as indicating vertical mixing. At Station 40 it constitutes 14% of the planktonic fauna, a high percentage which indicates a pre-Holocene age for sediments exposed at this locality.

Genus SPHAEROIDINELLA Cushman, 1927

SPHAEROIDINELLA DEHISCENS (Parker and Jones)

Plate 13, figures 1-3

Sphaeroidina bulloides d'Orbigny var. *dehiscens* PARKER and JONES, 1865, Roy. Soc. London, Philos. Trans., vol. 155, p. 369, pl. 19, fig. 5.

Specimens identified as *Sphaeroidinella dehiscens* include forms designated as *Sphaeroidinella dehiscens excavata* by Ban-

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PLATE 9

Figures — Page

1-7. *Globigerinoides quadrilobatus sacculifer* (Brady) (X100) 46
1. Umbilical view; Station 46
2. Umbilical view; Station 46
3. Spiral view; Station 46
4. Umbilical view; Station 46
5. Spiral view; Station 46
6. Spiral view; Station 46
7. Spiral view; Station 46

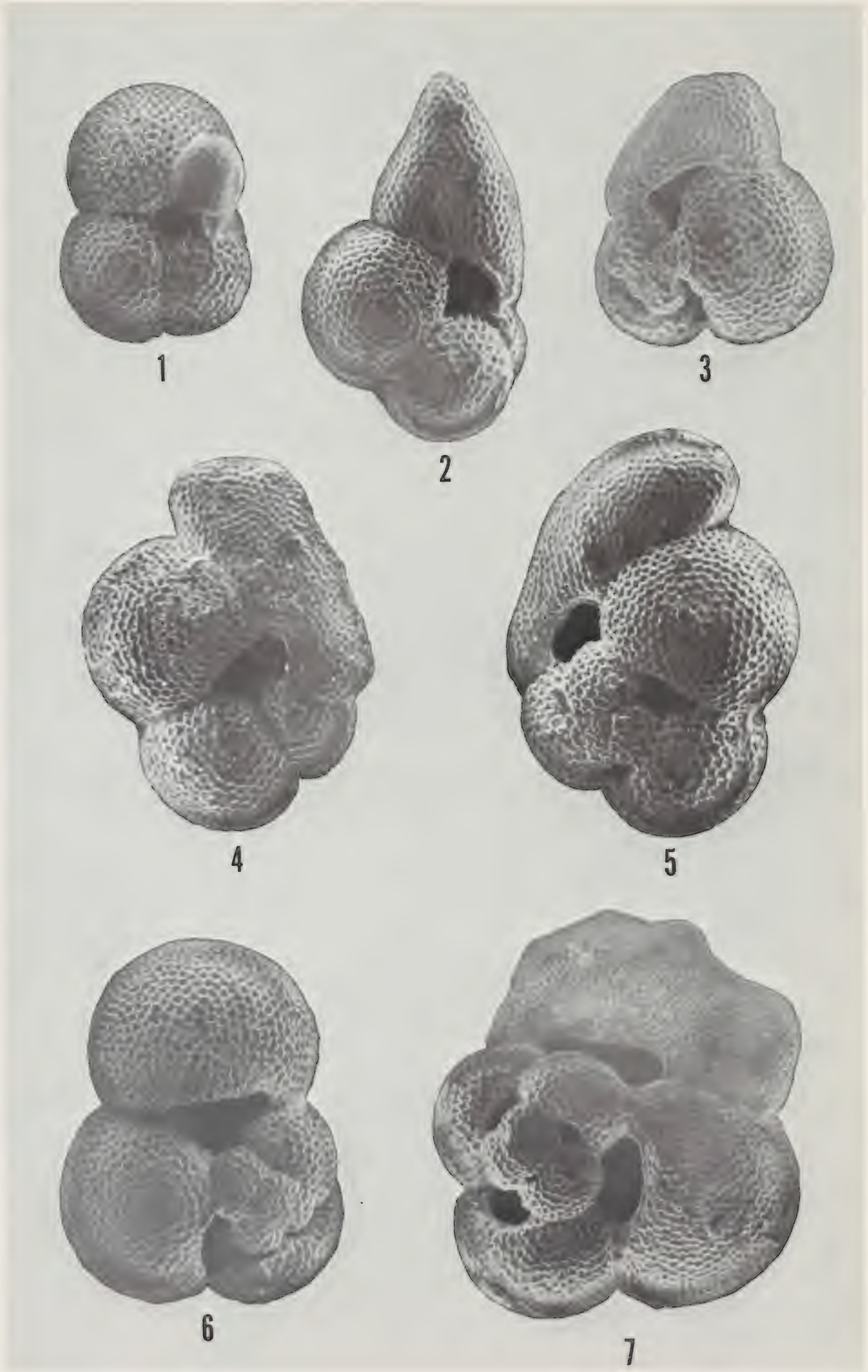

PLATE 9

ner and Blow (see pl. 13, fig. 3). The writer does not recognize this subspecies because its diagnostic features appear to be related to size and, hence, to the maturity of the specimen. The form is interpreted as a developmental stage that is simply not attained by the majority of specimens.

Sphaeroidinella dehiscens occurs within surface sediments at scattered localities throughout the Gulf of Mexico (fig. 30). At no single locality does it account for more than 1% of the planktonic foraminiferal fauna.

Living specimens flourish in temperatures ranging from 16 to 20°C and at depths between 200 and 300 meters (fig. 2). Given the optimum depth range of this species, it is not surprising that its distributional patterns in surface sediments indicate no clear relationship to temperature changes in surface waters. As solution is not likely to alter the relative abundance of *Sphaeroidinella dehiscens* (see table 1), its patchy distribution is best explained by its low relative abundance (below 5%) in living planktonic foraminiferal populations (Bradshaw, 1959, p. 49).

Family CANDEINIDAE Cushman, 1927
Genus CANDEINA d'Orbigny, 1839
CANDEINA NITIDA d'Orbigny
Plate 13, figures 4-6

Candeina nitida D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, p. 108, pl. 2, figs. 27-28.

Like *Sphaeroidinella dehiscens, Candeina nitida* has an irregular distribution and is present only in relative abundance below 1% of the planktonic fauna (fig. 31). It flourishes in temperatures above 20°C, salinities above 36 ‰ , and at depths from the surface to 300 meters (fig. 2). Its distributional pattern in surface sediments of the study area is too irregularly scattered to attempt correlation with temperature and salinity values in the overlying surface waters.

Genus GLOBIGERINITA
Bronnimann, 1951
GLOBIGERINITA GLUTINATA Egger
Plate 14, figures 1-5

Globigerinita glutinata EGGER, 1893, Abhandl. K. Bayer. Akad. Wiss. Munchen, CLII, vol. 18, p. 371, pl. 13, figs. 19-21.

Specimens with the umbilical bulla are readily recognizable as *Globigerinita glutinata.* Some specimens lacking the bulla are chambered much like immature *Globigerinoides quadrilobatus quadrilobatus;* however, the smooth to finely hispid surface of *Globigerinita glutinata* serves to distinguish such specimens from the coarsely cancellate *Globigerinoides quadrilobatus quadrilobatus.* Other specimens may resemble *Globigerina falconensis,* but are distinguished by their less hispid surface and the less prominent apertural lip. In some instances, identification of a particular specimen is arbitrary.

Globigerinita glutinata is the second most abundant planktonic species in surface sediments of the Gulf of Mexico (fig. 32). Over most of the area relative abundances range from 10 to 20% with concentrations of 15 to 20% in the western and central portions and of 10 to 15% in the south-central and eastern portions. Relative abundances of 5 to 10%

PLATE 10

Figures Page

1-9. *Globigerinoides ruber* (d'Orbigny) (X100) 46

1. Umbilical view; Station 46
2. Umbilical view; Station 72
3. Umbilical view; Station 72, immature form with four peripheral chambers
4. Umbilical view; Station 46
5. Umbilical view; Station 46
6. Spiral view; Station 46
7. Umbilical view; Station 72
8. Spiral view; Station 72
9. Spiral view; Station 72

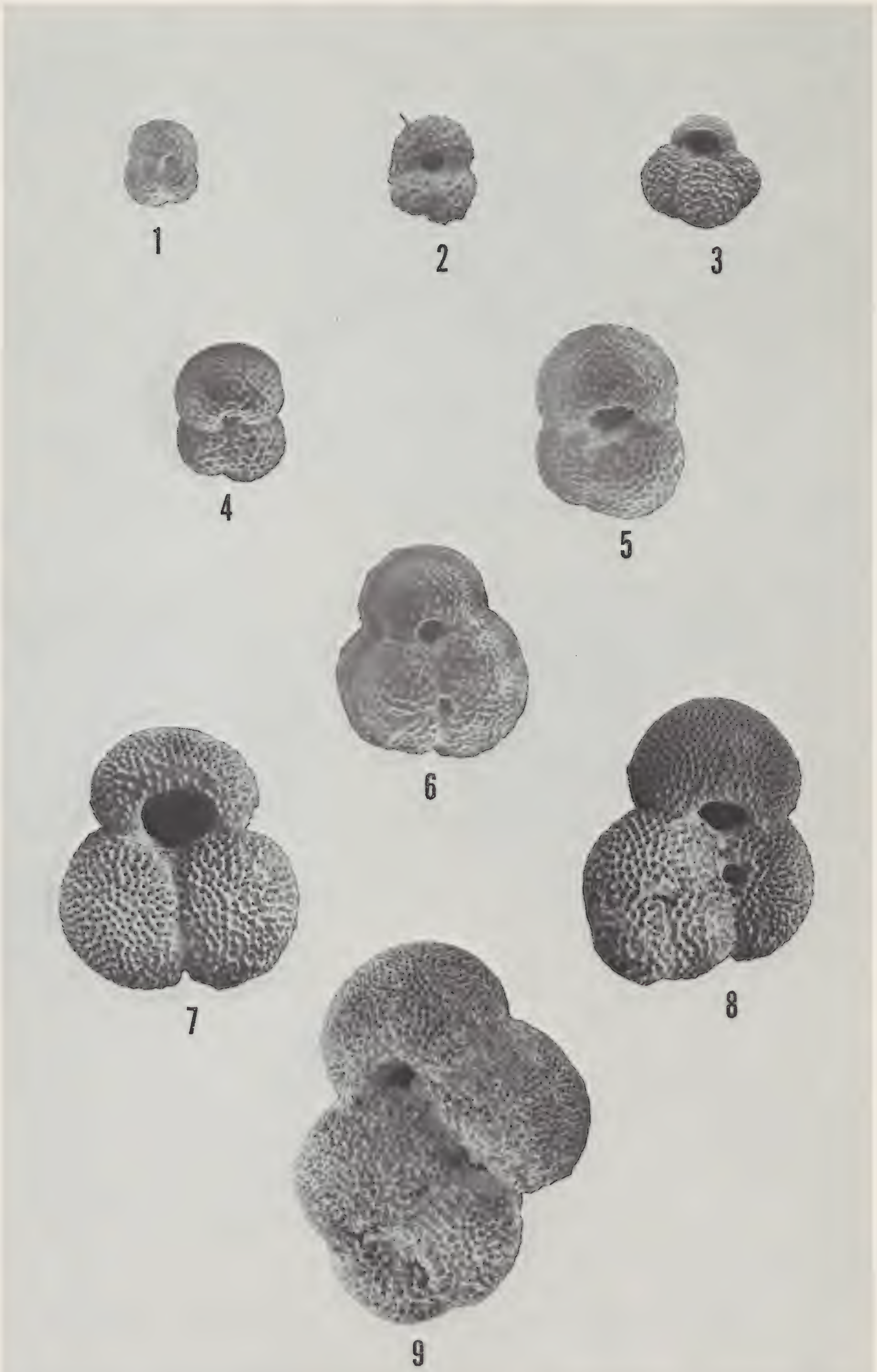

PLATE 10

are present only in the extreme southeastern portion of the study area. Concentrations between 20 and 25% occur locally through northern portions of the Gulf, but the highest concentrations (25 to 30%) are situated only along the continental slope off Louisiana and off the eastern Alabama-western Florida coast.

This species is the most cosmopolitan of modern planktonic foraminifers. It flourishes in temperatures ranging from 11 to 30°C, salinities from 34 to more than 36 ‰ , and from the surface to depths of 250 meters (fig. 2).

Although the distributional pattern of *Globigerinita glutinata* generally does not reflect changes in temperature or salinity within the overlying surface waters, areas with concentrations above 20% occur only in the northern limits of the study area (fig. 32). Because this species thrives in such a wide range of temperatures and salinities, this pattern cannot be attributed to the presence of critical temperature and/or salinity thresholds. This area of maximal development does, however, correspond well with the area of minimal development exhibited by *Globigerinoides ruber.* The relative abundance of *Globigerinita glutinata* in this area may well be related to the decline of *Globigerinoides ruber,* rather than being directly dependent upon temperature and salinity values. This species may become numerically dominant under conditions where *Globigerinoides ruber* cannot.

GLOBIGERINITA IOTA Parker
Plate 14, figures 6-10

Globigerinita iota PARKER, 1962, Micropaleontology, vol. 8, no. 2, p. 250, pl. 10, figs. 26-30.

Globigerinita iota and immature specimens of *Globigerina quinqueloba* are similar but can be differentiated on the basis of the shell material covering the umbilicus. In *Globigerinita iota* this material is a bulla; in *Globigerina quinqueloba,* a modified final chamber. Also, *Globigerina quinqueloba* is more coarsely hispid.

Except for the southeastern portion of the Gulf of Mexico where it is consistently present, *Globigerinita iota* occurs in scattered, isolated patches throughout the study area (fig. 33). At no sampling station does the relative abundance of this species exceed 1% of the planktonic assemblage. There is no clear relationship between its distribution and that of temperature and salinity values.

GLOBIGERINITA UVULA (Ehrenberg)
Plate 14, figures 11-13

Pylodexia uvula EHRENBERG, 1861, K. Preuss. Akad. Wiss. Berlin, Monatsber., pp. 276, 277, 308.

Globigerinita uvula occurs in surface sediments at only a few stations in the study area (fig. 34). Its relative abundance in these isolated occurrences is less than 1% of the planktonic assemblage.

This subpolar species flourishes in temperatures below 10°C, salinities between 34 and 34.5 ‰ , and at depths below 250 meters (fig. 2). The irregular distribution of the species is probably caused by its low optimum temperature range. Even at depth, water temperatures in the Gulf of Mexico would not support large numbers of living specimens. This scarcity of living specimens may produce the "spotty" distribution.

Family CATAPSYDRACIDAE Bolli, Loeblich, and Tappan, 1957

Genus GLOBOQUADRINA Finlay, 1947 (emended)

PLATE 11

Figures Page
1. *Orbulina bilobata* (d'Orbigny) (X100) 11
Station 46
2-3. *Orbulina universa* d'Orbigny (X100) 11
2. Station 46
3. Station 46
4. *Orbulina suturalis* Bronnimann (X100) 50
Station 46

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PLATE 11

GLOBOQUADRINA DUTERTREI
(d'Orbigny)
Plate 15, figures 1-11

Globigerina dutertrei D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, p. 84.

Although quite variable, *Globoquadrina dutertrei* is distinct from most other species. The practical separation of immature forms of this species, in which the aperture becomes umbilical early in ontogeny, from some specimens of *Globigerina pachyderma* is based upon the coarser surface texture and umbilical-extraumbilical aperture of the latter.

Globoquadrina dutertrei comprises 1 to 3% of the planktonic fauna in surface sediments of the western, southeastern, and extreme northwestern portions of the Gulf of Mexico (fig. 35). Concentrations between 3 and 5% occur over large regions in the eastern portion of the study area. Relative abundances above 5% occur in the north-central and northeastern Gulf of Mexico; those below 1%, only in the northwestern portion.

This warm-temperate species thrives in temperatures between 17 and 23°C, salinities above 35.5 ‰, and from the surface to depths of 150 meters (fig. 2). It tolerates such a wide range of temperatures that its distribution does not reflect changes in surface and near-surface water temperatures of the Gulf of Mexico. However, relative concentrations of *Globoquadrina dutertrei* are affected by the amount of post-depositional solution. It is among the planktonic species that are resistant to solution (table 1) and comprises more than 10% of the planktonic assemblage only at stations bearing evidence of solution.

Genus PULLENIATINA Cushman, 1927

PULLENIATINA OBLIQUILOCULATA OBLIQUILOCULATA (Parker and Jones)
Plate 12, figures 7-8

Pullenia obliquiloculata PARKER and JONES, 1862, *in* W. H. CARPENTER, Ray Soc., p. 183 (nomen nudum).

Pullenia sphaeroides obliquiloculata PARKER and JONES, 1865, Roy. Soc. London, Philos. Trans., vol. 155, p. 365, pl. 19, fig. 4.

Because this subspecies is rare and there is doubt about distinguishing immature specimens from the young of *Pulleniatina obliquiloculata finalis* (see discussion under this subspecies), percentages were not calculated for it. The two subspecies are lumped together in a category described as the "*Pulleniatina obliquiloculata* complex."

PULLENIATINA OBLIQUILOCULATA FINALIS Banner and Blow
Plates 16 and 17

Pulleniatina obliquiloculata finalis BANNER and BLOW, 1967, Micropaleontology, vol. 13, no. 2, p. 140, pl. 2, figs. 4-10; pl. 3, fig. 5; pl. 4, fig. 10.

The dissection of many specimens has revealed that *Pulleniatina obliquiloculata finalis* undergoes a marked change during its ontogenetic development (pl. 17, figs. 1-12). Initially the test is globigerinid in that it is trochospirally coiled, with an umbilicus, an umbilical aperture, and a hispid wall. Be-

PLATE 12

Figures Page

1-2. *Hastigerina pelagica* (d'Orbigny) (X100) 50
1. Edge view; Station 46
2. Side view; Station 46
3-6. *Pseudohastigerina praepumilio* (Parker) (X200) 52
3. Side view; Station 40
4. Edge view; Station 40
5. Edge view; Station 40
6. Side view; Station 40
7-8. *Pulleniatina obliquiloculata obliquiloculata* (Parker and Jones) (X100) 58
7. Dorsal view; Station 72
8. Edge view; Station 72

PLATE 12

cause of a transition toward streptospiral coiling (pl. 17, figs. 6-8) the umbilicus is lost and the aperture progresses toward its adult condition, described as "pseudoumbilical" by Banner and Blow (1967, p. 136). After the mode of coiling changes, the hispid nature of the surface is gradually lost. The rate at which this final step occurs seems to vary from specimen to specimen. The dissection series (pl. 17) is the evidence upon which the growth series (pl. 16, figs. 1-11) is based.

Although adult specimens of the two infraspecific taxa here discussed are distinguishable, the immature forms cause problems. As so few specimens of *Pulleniatina obliquiloculata* sensu stricto were available, extensive dissections were impossible. The precise ontogenetic development is unknown but it is apt to be quite similar to, if not indistinguishable from, that of *Pulleniatina obliquiloculata finalis.* Hence, the two are treated as a single taxon for the purpose of distributional analysis. This fact does not, however, cast doubt upon the growth series presented for *Pulleniatina obliquiloculata finalis.*

The two subspecies of *Pulleniatina obliquiloculata* constitute 5 to 10% of the planktonic assemblage in the west-central portion of the Gulf of Mexico (fig. 36). Areas with concentrations between 3 and 5% are situated in the southwestern, eastern, and extreme northwestern portions of the Gulf. Concentrations from 1 to 3% occur primarily in the central part of the study area; those below 1%, only along the continental slope in its northern portion.

Pulleniatina obliquiloculata is a subtropical species that flourishes in temperatures between 19 and 25°C, salinities above 36 ‰, and from the surface to depths of 150 meters (fig. 2). Because surface and near-surface water temperatures remain above 18°C (figs. 3 and 4) during the entire year, cool waters do not curtail its distribution in the Gulf of Mexico. However, summer temperatures are more than 29°C in a tongue-shaped area extending southeastward from the Louisiana coast (fig. 3). Such high temperatures may exclude the species from this area during the warmer seasons, thus reducing concentrations in the sediments below. This species is resistant to solution (table 1) and high relative concentrations may occur where solution rates are high.

Family GLOBOROTALIIDAE Cushman, 1927

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA CRASSIFORMIS (Galloway and Wissler)

Plate 18, figures 1-6

Globigerina crassiformis GALLOWAY and WISSLER, 1927, Jour. Paleontology, vol. 1, p. 41, pl. 7, fig. 12.

It is sometimes difficult to separate this species from *Globorotalia hirsuta.* In adult specimens the chambers of *Globorotalia crassiformis* are more inflated, the spiral side of the test more flattened, and the wall more coarsely granular. However, these distinguishing features decrease in prominence in immature forms. When dealing with small specimens the inflation of the chambers seems to be the most consistent difference, but when the diameter of specimens is less than 0.15 mm the distinction between the two species becomes arbitrary.

PLATE 13

Figures — Page

1-3. *Sphaeroidinella dehiscens* (Parker and Jones) 52
1. Umbilical view, X 100; Station 46
2. Umbilical view, X 100; Station 46
3. Umbilical view, X 61; Station 46
4-6. *Candeina nitida* d'Orbigny 54
4. Oblique view, X 100; Station 46
5. Side view, X 100; Station 46
6. Side view, X 150; Station 46; immature specimen showing small primary aperture

PLATE 13

Globorotalia crassiformis constitutes less than 1% of the planktonic assemblage over most of its area of occurrence (fig. 37). Distribution is rather irregular and the species is absent from sediments over large portions of the central and northern Gulf of Mexico. Scattered occurrences with concentrations between 1 and 5% occur in northern portions of the study area.

This warm-temperate to subtropical species thrives in temperatures between 16 and 26°C, salinities above 35.5 ‰ , and at depths between 150 and 200 meters (fig. 2). Although temperature changes in overlying surface waters do not affect its distribution, this species is absent from sediments underlying areas where surface currents are absent. Hence, adequate circulation may be an important factor in limiting its distribution.

GLOBOROTALIA FLEXUOSA (Koch)
Plate 21, figures 8-9

Pulvinulina tumida flexuosa KOCH, 1923, Eclogae Geol. Helv., vol. 18, p. 357, figs. 9-10.

Lamb and Beard (1972) recognize the extinction level of *Globorotalia flexuosa* in the late Wisconsin glacial stage in the Gulf of Mexico. Ericson and Wollin (1968, p. 1232) and Emiliani (1969, p. 271) also record the extinction level in the last glacial period. Parker (1967, p. 182) states that flexuose forms occur intermittently throughout the section in Indo-Pacific cores. Adegoke, *et al.* (1971, p. 199) record the occurrence of a few specimens of this form in surface sediments of the Gulf of Guinea. These latter authors state that Boltovskoy (1968), in his study of living planktonic Foraminifera in the eastern equatorial Atlantic, recorded two specimens in the plankton. Bé and McIntyre (1970, p. 595) record living specimens from 47 plankton stations in the northern Indian Ocean.

Globorotalia flexuosa occurs only in a few, widely scattered localities in the Gulf of Mexico (fig. 38). Its relative abundance is generally less than 1% of the planktonic fauna.

Because of its close affinity to *Globorotalia tumida,* it is believed to have thrived in subtropical conditions. However, it became extinct in the Gulf of Mexico during the late Pleistocene (Lamb and Beard, 1972, p. 42). Its presence in surface sediments is evidence that either pre-Holocene sediments are exposed, or that vertical mixing has occurred. Sediments at stations 25 and 40 are interpreted as pre-Holocene, but other occurrences are considered to be the result of mixing.

GLOBOROTALIA HIRSUTA (d'Orbigny)
Plate 19, figures 1-5

Rotalina hirsuta D'ORBIGNY, 1839, *in* BARKER-WEBB and BERTHELOT, Hist. Nat. Iles

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PLATE 14

Figures Page

1-5. *Globigerinita glutinata* (Egger) (X200) 54
1. Umbilical view; Station 24
2. Spiral view; Station 52
3. Umbilical view; Station 52
4. Umbilical view; Station 46
5. Umbilical view; Station 68
6-10. *Globigerinita iota* Parker (X150) 56
6. Umbilical view; Station 46
7. Umbilical view; Station 28
8. Edge view; Station 31
9. Spiral view; Station 46
10. Umbilical view; Station 46
11-13. *Globigerinita uvula* (Ehrenberg) (X200) 56
11. Apertural view; Station 26
12. Spiral view; Station 28
13. Apertural view; Station 46

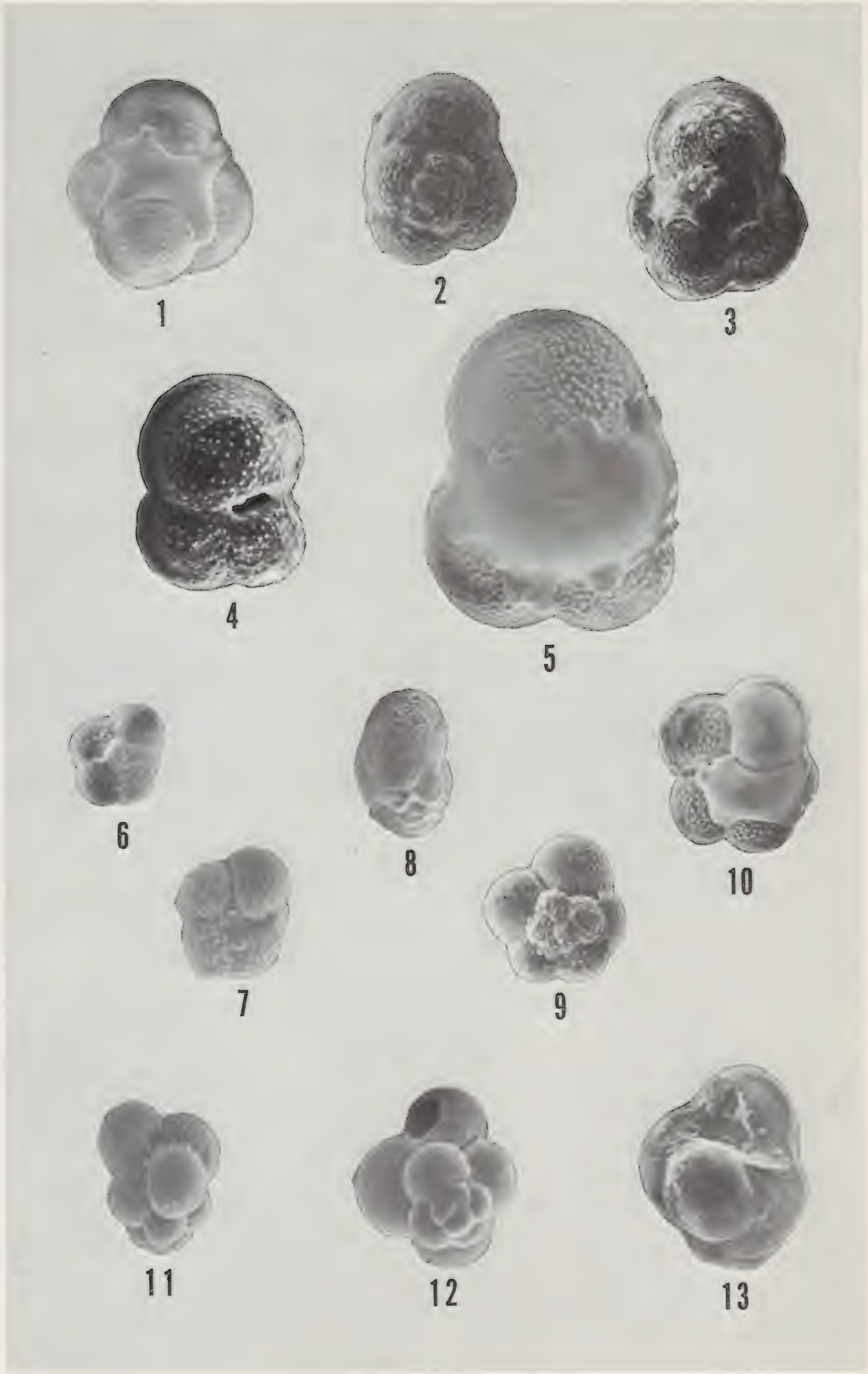

PLATE 14

Canaries, vol. 2, pt. 2, Zoology, p. 131, pl. 1, figs. 37-39.

As stated under the discussion of *Globorotalia crassiformis,* separating that species from *Globorotalia hirsuta* can be difficult, especially the immature forms. Distinguishing characters are the less inflated chambers, more acute periphery, and the convexity of the spiral side in *Globorotalia hirsuta.*

Globorotalia hirsuta constitutes less than 1% of the planktonic fauna in surface sediments of the Gulf of Mexico (fig. 39). This species is present along the continental slope from Texas to Florida. There are also isolated occurrences in the central and southern Gulf area. At only one station, on the continental slope off the coast of eastern Texas, does its relative abundance exceed 1%.

Globorotalia hirsuta is a temperate species that flourishes in temperatures between 18 and 21°C, salinities above 35 ‰, and at depths from 100 to 250 meters (fig. 2). Its distribution is influenced by surface current systems in the Gulf of Mexico (fig. 6). The species is present in areas of active mixing and generally absent from central portions of the study area where circulation is poor.

GLOBOROTALIA INFLATA (d'Orbigny)
Plate 19, figures 6-10

Globigerina inflata D'ORBIGNY, 1839, *in* BARKER-WEBB and BERTHELOT, Hist. Nat. Iles Canaries, vol. 2, pt. 2, Zoology, p. 134, pl. 2, figs. 7-9. ,

The closest morphologic affinities of *Globorotalia inflata* are to *Globorotalia crassiformis.* However, *Globorotalia inflata* has more inflated chambers, a more rounded periphery, and greater apertural height. These characters are quite consistent and useful, even in immature specimens.

Occurrences of *Globorotalia inflata* are primarily along the continental slope in northern portions of the Gulf of Mexico (fig. 40). Here concentrations of this species range from below 1% to nearly 10% of the planktonic assemblage. Isolated, widely scattered occurrences, only one of which has a relative abundance above 1%, are present farther to the south.

Globorotalia inflata is described as a cold-temperate species that thrives in temperatures between 13 and 17°C, salinities from 34 to 36 ‰ , and at depths from 100 to 150 meters (fig. 2). It is present in living populations from higher latitudes but has been excluded from the Gulf of Mexico since the earliest Holocene (Lamb and Beard, 1972, p. 42). Although its distribution is generally limited to the coolest, least saline portions of the Gulf, water temperatures are not low enough to provide optimum conditions. Hence, its presence in significant numbers in surface sediments from the study area indicates sediments deposited during the cooler Pleistocene climate. Smaller concentrations are evidence of vertical mixing.

GLOBOROTALIA MENARDII (d'Orbigny)
Plate 20, figures 1-3

PLATE 15

Figures — Page

1-11. *Globoquadrina dutertrei* (d'Orbigny) (X100) 58
1. Umbilical view; Station 46
2. Umbilical view; Station 46; dissected from adult specimen
3. Umbilical view; Station 46
4. Umbilical view; Station 46; dissected from adult specimen
5. Umbilical view; Station 46
6. Umbilical view; Station 46
7. Edge view; Station 46
8. Spiral view; Station 46
9. Umbilical view; Station 46
10. Umbilical view; Station 46; morphologic variant
11. Umbilical view; Station 46; morphologic variant

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PLATE 15

Rotalia menardii D'ORBIGNY, 1826, Ann. Sci. Nat., (ser. 1) vol. 7, p. 273.

Globorotalia menardii is quite distinct and readily separated from other species encountered in the study area. However, immature specimens may be difficult to distinguish from immature *Globorotalia ungulata.* The latter species has more strongly inflated chambers, particularly the ultimate chamber of the final whorl.

Globorotalia menardii constitutes 1 to 3% of the planktonic foraminiferal assemblage over most of the Gulf of Mexico (fig. 41). Sediments in which the relative abundance of this species is below 1% are generally along the continental slope in the northern Gulf area. A large region in the central and south-central portions of the study area has concentrations ranging from 3 to 5%. Areas with relative abundances ranging from 5 to 10% are sparsely scattered through the central and southern portions of the region.

Globorotalia menardii is a subtropical species that flourishes in temperatures between 17 and 25°C, salinities above 36 ‰ , and at depths from 100 to 150 meters (fig. 2). Although its distributional pattern does not reflect changes in surface water temperatures and salinity, there is a relationship to surface current systems. The higher relative concentrations of this species (3-10%) occur in the central portion of the study area where circulation is poor (fig. 6). *Globorotalia menardii* is perhaps better adapted to such conditions than most other planktonic species.

GLOBOROTALIA SCITULA (Brady)
Plate 20, figures 4-5

Pulvinulina scitula BRADY, 1882, *in* TIZARD and MURRAY, Roy. Soc. Edinburgh, Proc., vol. 11, p. 716.

Globorotalia scitula constitutes less than 1% of the planktonic fauna in surface sediments over most of the Gulf of Mexico (fig. 42). Concentrations between 1 and 3% occur on or near the continental slope in the northern Gulf area and are widely scattered over its central and southern portions. Concentrations from 3 to 5% occur at only two localities, both in the central Gulf area.

Globorotalia scitula is a temperate species, which thrives in temperatures between 15 and 17°C (Boltovskoy, 1966). However, the species has been recorded in living populations where temperatures are as low as 3.5°C (Boltovskoy, 1971) and as high as 29°C (Bradshaw, 1959). It attains maximum abundances at depths of 200 to 300 meters (fig. 2). The ability of this species to tolerate a wide range of temperatures explains why its distribution does not reflect changes in surface water temperature in the Gulf of Mexico.

GLOBOROTALIA AKERSI Snyder
Plate 22, figures 8-9

Globorotalia akersi SNYDER, 1975, Tulane Stud. Geol. Paleont., vol. 11, no. 4, p. 302, pls. 1, 2.

Globorotalia akersi constitutes less than 1% of the planktonic fauna in one small area of the south-central Gulf of Mexico (fig. 43). The reasons for this limited distribution are not clear.

GLOBOROTALIA TRUNCATULINOIDES (d'Orbigny)
Plate 21, figures 1-4

Rotalina truncatulinoides D'ORBIGNY, 1839, *in* BARKER-WEBB and BERTHELOT, Hist. Nat. Iles Canaries, vol. 2, pt. 2, p. 132, pl. 2, figs. 25-27.

Globorotalia truncatulinoides constitutes between 1 and 3% of the planktonic fauna

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PLATE 16

Figures — Page

1-11. *Pulleniatina obliquiloculata finalis* Banner and Blow, growth series, specimens from Station 72 and Station 73 (X100) 58
1-8. Umbilical view
9. Edge view
10. Dorsal view
11. Ventral view

PLATE 16

throughout most of the Gulf of Mexico (fig. 44). Concentrations below 1% occur in the southeastern extremity of the study area and in isolated patches in its central portion. Relative abundances from 3 to 10% are present in the south-central, western, and northwestern regions of the Gulf. A small area off the coast of Florida has concentrations between 3 and 5%.

This species attains its maximum development in living communities with temperature conditions between 15 and 22°C, salinities from 35 to 37 ‰ , and at depths from 100 to 225 meters (fig. 2). Its distributional pattern in surface sediments of the Gulf of Mexico does reflect changes in temperatures at a depth of 100 meters in the overlying waters. Concentrations above 3% occur only in areas where temperatures at this depth remain below 22°C during the entire year (fig. 4). In addition, relative abundances below 1% are encountered only where year-round temperatures at a depth of 100 meters are 24°C or more.

GLOBOROTALIA TUMIDA (Brady)
Plate 21, figures 5-7

Pulvinulina menardii var. *tumida* BRADY, 1877, Geol. Mag., (new ser., dec. 2) vol. 4, no. 12, p. 535.

Globorotalia tumida is distinguished from *Globorotalia menardii* by its greater elongation, greater thickness, and coarser surface texture. It is difficult to separate some specimens from *Globorotalia ungulata.* Most specimens of the latter species are less elongate, possess a finer surface texture, and have a much more acute umbilical shoulder than *Globorotalia tumida.* However, specimens with morphological similarities to both of these species do occur. The large, tumid forms of *Globorotalia tumida* are indicators of Holocene sediments.

Globorotalia tumida constitutes less than 1% of the planktonic foraminiferal fauna in surface sediments throughout the northcentral and northeastern portions of the Gulf of Mexico (fig. 45). Except for one large area in the southeastern portion, concentrations between 1 and 3% occur only as small, isolated patches irregularly scattered over the study area. Only at one station, in the south-central Gulf of Mexico, does the relative abundance of this species exceed 3%.

Globorotalia tumida is a subtropical species that thrives in temperatures between 19 and 30°C and from the surface to depths of 300 meters (fig. 2). The distributional pattern of this species in surface sediments reflects temperature changes in overlying surface waters. Relative concentrations above 1% occur only in those areas with year-round surface water temperatures above 23°C (fig. 4). Isolated occurrences of concentrations above 1% may be related to solution phenomena. Because *Globorotalia tumida* is the planktonic foraminifer with the highest resistance to solution (table 1), local concentrations may be created by the preferential solution of less resistant species. The absence of the species at several localities in the southeastern Gulf is baffling. The author can offer no explanation for such absence in an area where concentrations above 1% would be expected.

GLOBOROTALIA UNGULATA Bermudez
Plate 22, figures 1-7

Globorotalia ungulata BERMUDEZ, 1961, Bol. Geologia (Venezuela), Spec. Pub. 3, p. 1304, pl. 15, fig. 6.

"Although the overall test shape is reminiscent of *Globorotalia tumida,* the very distinctive thin, delicate, finely perforate test wall enables this form to be recognized easily" (Lamb and Beard, 1972, p. 57). Indeed, the two species are quite similar in terms of chambering, peripheral outline, and apertural characters. Surface texture, the distinguishing feature mentioned above, is usually adequate to differentiate members of the two species. Lesser elongation of the cham-

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PLATE 17

Figures Page

1-12. *Pulleniatina obliquiloculata finalis* Banner and Blow, dissection series; specimens from Station 72 and Station 73; all apertural views (X100) 58

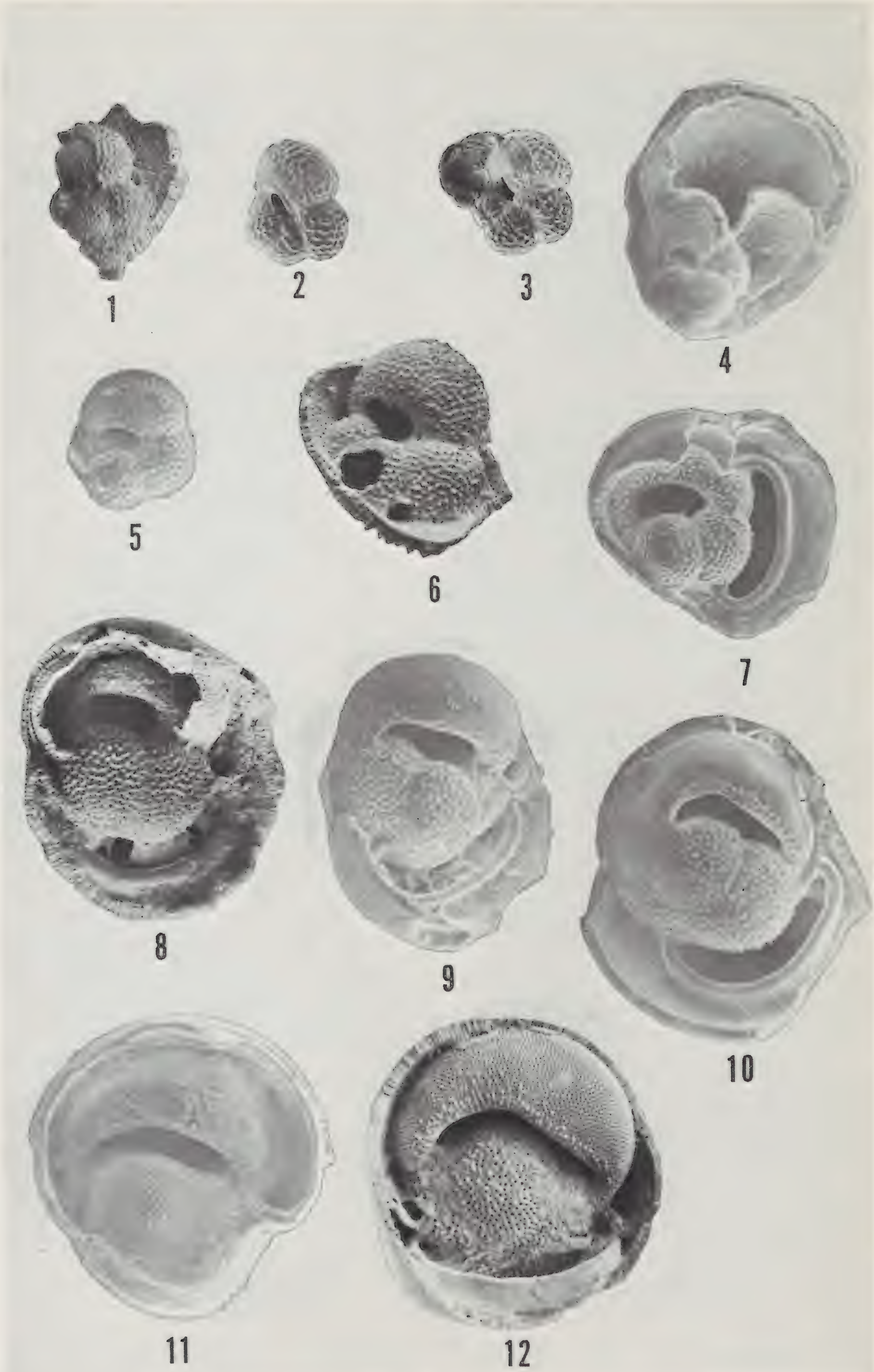

PLATE 17

bers and a more acute umbilical shoulder are other features of *Globorotalia ungulata* useful in differentiation. However, as mentioned earlier, transitional forms exist. These two "species" may be merely growth forms of the same species. Other than *Globorotalia tumida,* no species is likely to be confused with *Globorotalia ungulata.* According to Lamb and Beard (1972, p. 57) this species is not found in sediments older than earliest Holocene.

Globorotalia ungulata constitutes less than 1% of the planktonic fauna in surface sediments of the western, south-central, and northeastern Gulf of Mexico (fig. 46). Concentrations between 1 and 3% occur over the remainder of the study area.

The distribution of this subtropical-tropical species in surface sediments reflects changes in temperature at a depth of 100 meters in the overlying waters. Relative concentrations above 1% occur only in areas where year-round temperatures at this depth are above 20°C (fig. 4).

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PLATE 18

Figures Page

1-6. *Globorotalia crassiformis* (Galloway and Wissler) (X150) 60

1. Umbilical view; Station 46
2. Umbilical view; Station 46
3. Umbilical view; Station 46
4. Edge view; Station 46
5. Umbilical view; Station 46
6. Spiral view; Station 46

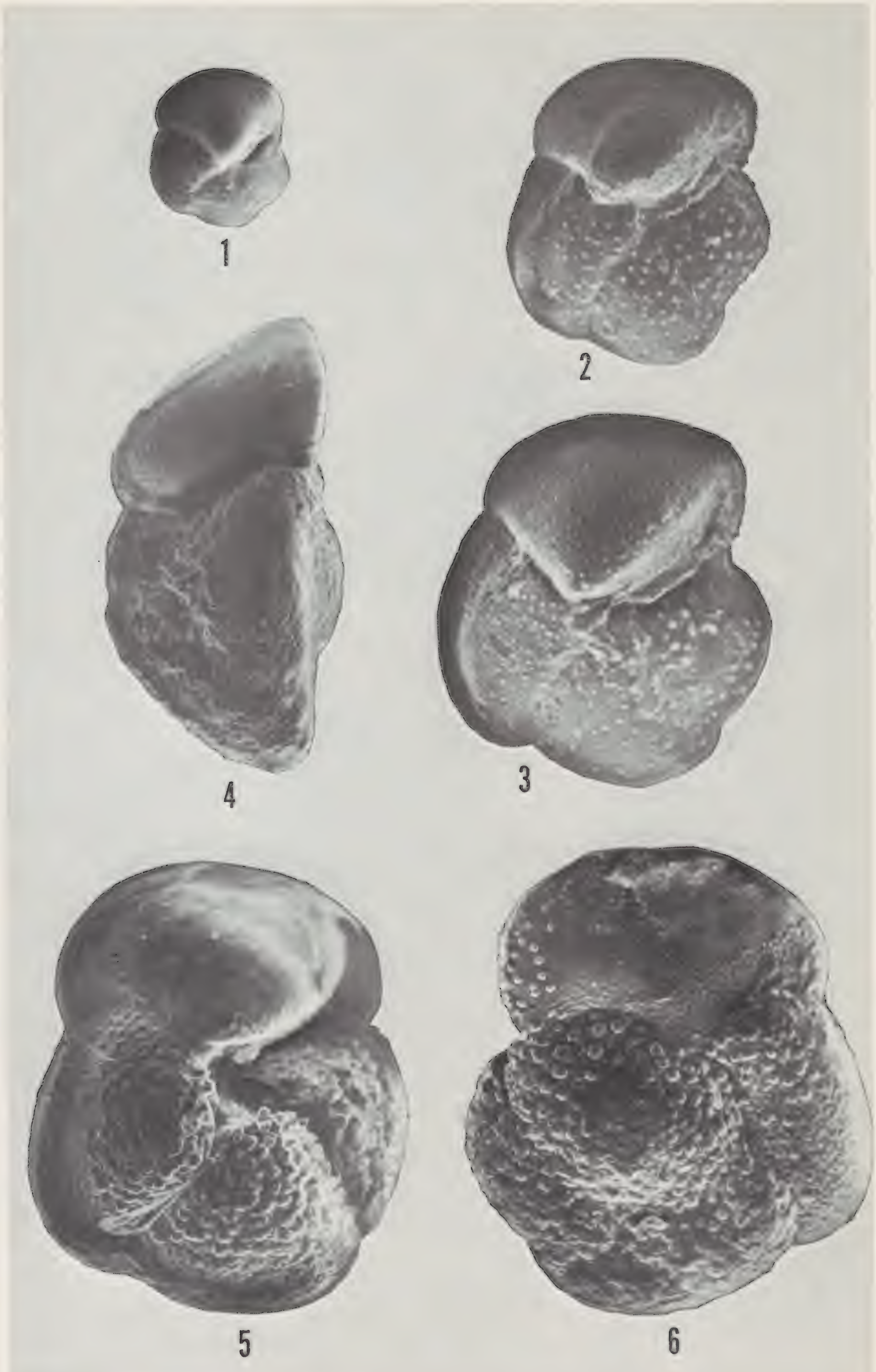

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PLATE 19

Figures Page

1-5. *Globorotalia hirsuta* (d'Orbigny) (X150) 62
1. Spiral view; Station 7
2. Edge view; Station 28
3. Umbilical view; Station 2
4. Edge view; Station 46
5. Umbilical view; Station 46
6-10. *Globorotalia inflata* (d'Orbigny) (X150) 64
6. Edge view; Station 50
7. Umbilical view; Station 50
8. Spiral view; Station 50
9. Edge view; Station 50
10. Umbilical view; Station 50

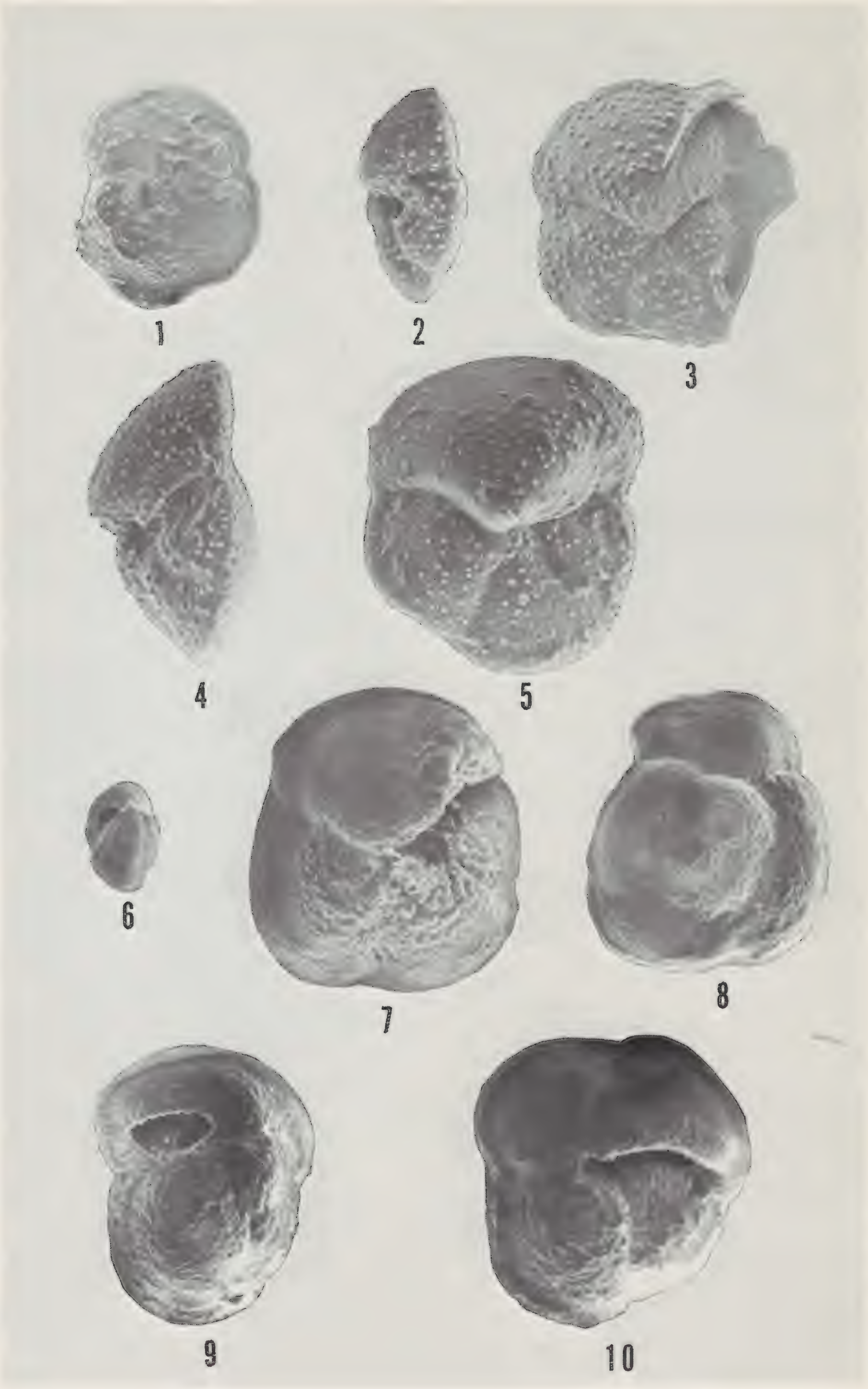

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PLATE 20

Figures Page

1-3. *Globorotalia menardii* (d'Orbigny) (X100) 64
1. Umbilical view; Station 46
2. Umbilical view; Station 72
3. Spiral view; Station 72
4-5. *Globorotalia scitula* (Brady) (X200) 66
4. Umbilical view; Station 46
5. Spiral view; Station 46

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PLATE 20

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PLATE 21

Figures Page

1-4. *Globorotalia truncatulinoides* (d'Orbigny) (X100) 66
1. Umbilical view; Station 46
2. Umbilical view; Station 46
3. Umbilical view; Station 72
4. Edge view; Station 72
5-7. *Globorotalia tumida* (Brady) (X100) 68
5. Umbilical view; Station 46
6. Edge view; Station 46
7. Spiral view; Station 46
8-9. *Globorotalia flexuosa* (Koch) 62
8. Umbilical view, X73; Station 46
9. Edge view, X65; Station 46

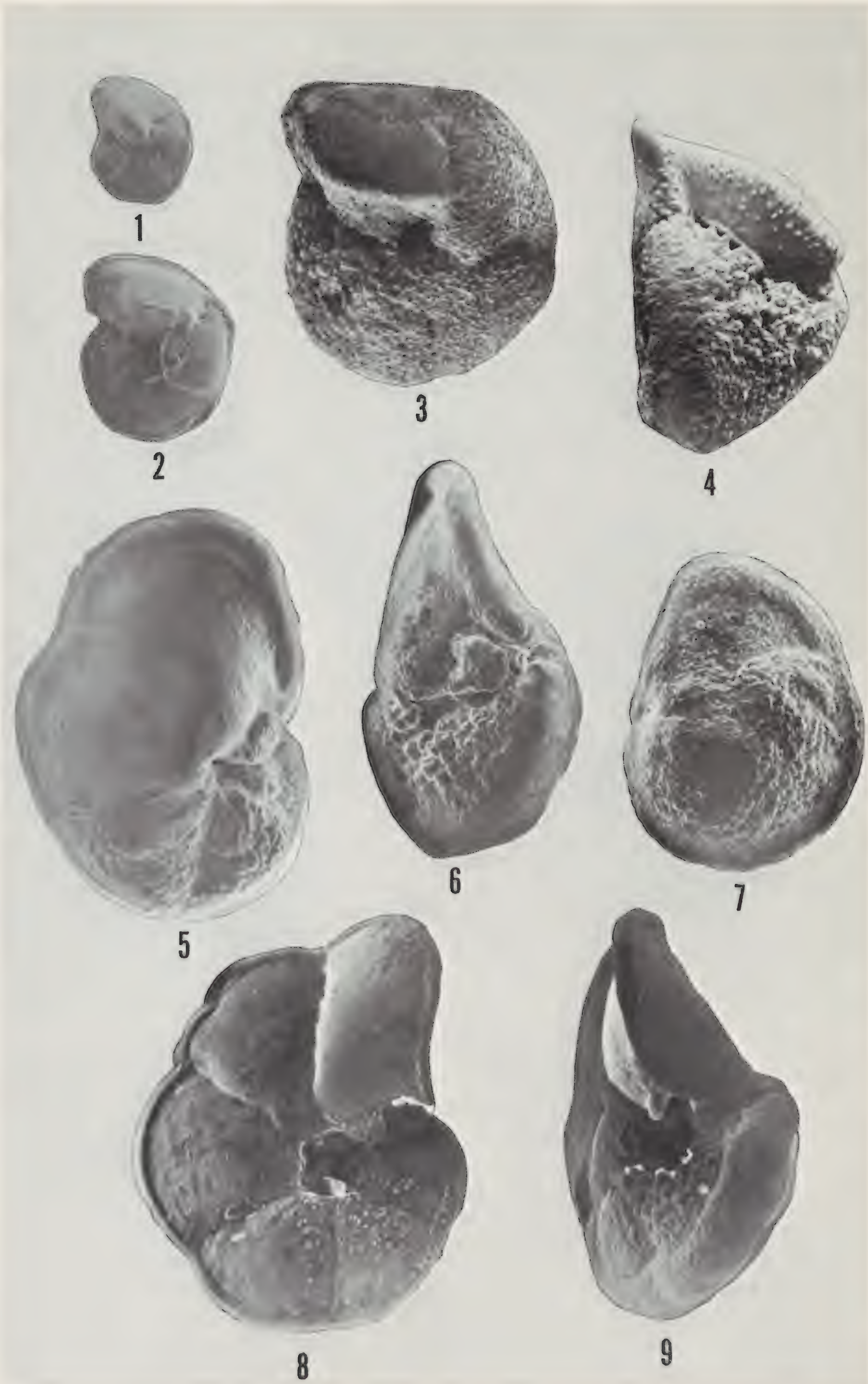

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PLATE 22

Figures Page

1-7. *Globorotalia ungulata* Bermudez (X100) 68
1. Umbilical view; Station 46
2. Umbilical view; Station 46
3. Umbilical view; Station 46
4. Umbilical view; Station 46
5. Umbilical view; Station 46
6. Edge view; Station 46
7. Spiral view; Station 46
8-9. *Globorotalia akersi* Snyder (X100) 66
8. Spiral view; Station 46
9. Umbilical view; Station 83

PLATE 22

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REVIEWS

FOSSIL ALGAE: Recent Results and Developments, edited by Erik Flügel. Published by Springer-Verlag, Berlin, Heidelberg and New York, 1977, xiii + 375 pp., 119 figures, 32 plates, $36.10

This book presents a review of recent progress in knowledge of algae and algal constructions and the role of algae as facies indicators and sedimentological factors in both Recent and ancient environments. It includes articles on the biology and morphology of blue-green algae, and on the ultrastructure of the calcareous algae. Twelve papers deal with algae and their sedimentary environments. The volume is the product of fifty-eight contributing authors from all parts of the world. The coverage of the subject is thorough and should prove to be of great value and interest to biologists as well as paleontologists and stratigraphers. The book is well illustrated and includes an index of generic and species names, as well as a subject index.

THE MEANING OF FOSSILS: Episodes in the History of Paleontology, second edition, by Martin J. S. Rudwick. Published by Science History Publications, USA, a division of Neale Watson Academic Publications, Inc., New York, 1977, xv + 287 pp., illus., cloth $15.00, paper $6.95

The first edition of this book appeared in 1972. It has been reissued with line corrections in the text and a new preface by Professor Rudwick at a reduced price and in paperback to encourage wider student use. The work is divided into five sections. *Fossil Objects* and *Natural Antiquities* treat the sixteenth and seventeenth centuries before paleontology, or even geology itself, had become codified and recognized as a distinct scientific discipline. The third chapter, *Life's Revolutions,* begins late in the eighteenth century with one of Cuvier's principal papers on extinction and continues to the year 1830. The fourth, *Uniformity and Progress,* treats the years between the appearance of Lyell's *Principles of Geology* and Darwin's *Origin of Species. Life's Ancestry,* the last chapter, deals with Bronn and Darwin and the later nineteenth century development of evolutionary theory.

In Martin Rudwick's own words, "this book makes no pretence at being an exhaustive or 'definitive' account of the history of paleontology," but presents his "own interpretation in a coherent and straightforward form, so that the non-specialist reader can at least see how the picture looks to *one* historian." This he has done ably and well.

—H.C.S.

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Volume 14, Numbers 2-4 December 28, 1978

Number 2

CRIBROLENTICULINA, A NEW GENUS OF THE FAMILY NODOSARIIDAE EHRENBERG, 1838 (FORAMINIFERIDA) p. 81

and

COMMENTS ON THE GENERA *MONTFORTELLA* LOEBLICH AND TAPPAN, 1963, AND *HETEROCIBICIDES* McCULLOCH, 1977 (FORAMINIFERIDA)

DREW HAMAN p. 103

Number 3

A REVIEW OF THE VOLUTID GENERA *LYRIA* AND *FALSILYRIA* (MOLLUSCA:GASTROPODA) IN THE TERTIARY OF THE WESTERN ATLANTIC

SHIRLEY E. HOERLE and EMILY H. VOKES p. 105

COMMENTS ON SUBFAMILIAL RELATIONSHIPS IN TWO AMPHI-AMERICAN MURICID GENERA – *ACANTHOTROPHON* AND *ATTILIOSA*

GEORGE E. RADWIN and ANTHONY D'ATTILIO p. 131

Number 4

A PLEISTOCENE OSTRACODE FAUNA FROM SOUTH FLORIDA

MERVIN KONTROVITZ p. 135

AN OLIGOCENE (ORELLAN) SIRENIAN FROM THE BUCATUNNA FORMATION OF ALABAMA

KENNETH WHETSTONE and LARRY D. MARTIN p. 161

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CRIBROLENTICULINA, A NEW GENUS OF THE FAMILY NODOSARIIDAE EHRENBERG, 1838 (FORAMINIFERIDA)

DREW HAMAN*
CHEVRON OIL FIELD RESEARCH COMPANY
LA HABRA, CALIFORNIA

CONTENTS

Page
I. ABSTRACT 81
II. INTRODUCTION 81
III. DISCUSSION 82
IV. SYSTEMATIC PALEONTOLOGY 90
V. ACKNOWLEDGMENTS 96
VI. REFERENCES 96

ILLUSTRATIONS

TEXT FIGURE 1 83
TEXT FIGURE 2 85
TEXT FIGURE 3 87
TEXT FIGURE 4 89
TEXT FIGURE 5 91
TEXT FIGURE 6 93
PLATE 1 95
PLATE 2 97
PLATE 3 99
PLATE 4 101

I. ABSTRACT

Specimens related to the *Lenticulina* Lamarck, 1804, – *Saracenaria* Defrance *in* de Blainville, 1824, – *Vaginulinopsis* Silvestri, 1904, morphologic plexus but which possess distinctive cribrate apertures are recorded from Pliocene strata (Zones N.18-N.21) in a well located on the Texas continental shelf. These specimens represent a new genus of the family Nodosariidae Ehrenberg, 1838, herein designated *Cribrolenticulina*. A new species *Cribrolenticulina akersi* is described and designated as the genotype. Morphologic variation and taxonomic affinities of the new genus are discussed. Apertural modifications, both chemical and mechanical are described.

II. INTRODUCTION

Loeblich and Tappan (1964a, p. C511), describe the apertures of members of the superfamily Nodosariacea Ehrenberg, 1938, as "peripheral or terminal, typically radiate, or may be slitlike or rounded." The same authors elaborated on this diagnosis in their

*Research Associate, Dept. of Geology, Tulane University, New Orleans

EDITORIAL COMMITTEE FOR THIS PAPER:
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analysis of the apertures of the family Nodosariidae Ehrenberg, 1838, when they stated (p. C512) that the apertures could be "simple, slitlike or radiate, peripheral in coiled forms, terminal in straight forms, may have apertural chamberlet, or may have elongate neck." Members of the sub-family Nodosariinae Ehrenberg, 1838, were described by these authors (p. C512) as possessing apertures which are "terminal, rounded, or radiate." Generic differentiation in this subfamily based on apertural characteristics has been accorded validity as exemplified by the genera *Chrysalogonium* Schubert, 1907, and *Cribrorobulina* Thalmann, 1947. Loeblich and Tappan (1964a) compare *Chrysalogonium* to *Nodosaria* Lamarck, 1812, and differentiate these genera on the basis of apertural characters. The same authors use the identical criterion to distinguish *Cribrorobulina* from *Lenticulina* Lamarck, 1804. The more exotic apertures exhibited by *Chrysalogonium* and *Cribrorobulina* although utilized by Loeblich and Tappan (1964a) in generic differentiation, are not detailed by these authors in their generic diagnoses as noted above. The Nodosariidae is discussed at lenght by Loeblich and Tappan (1974) and the different types of aperture belonging to this family are described. Again, however, cribrate apertures are not mentioned.

Specimens representing a new genus of the Nodosariinae were retrieved from Pliocene sediments encountered in a well located on the Texas continental shelf (Continental Offshore Stratigraphic Test, COST #1, South Padre Island). These specimens are related to the *Lenticulina* Lamarck, 1804 — *Saracenaria* Defrance *in* de Blainville, 1824 — *Vaginulinopsis* Silvestri, 1904, plexus but are differentiated by the cribrate aperture they possess.

III. DISCUSSION

A. THE APERTURE AS A TAXONOMIC CRITERION

Two schools of thought exist concerning the validity of using apertural characteristics for taxonomic differentiation on a generic level or on any other taxonomic level. One group opposes the use of this criterion and the other supports the validity of this feature.

Glaessner (1945) and Cushman (1948) regarded the aperture as being a morphocharacter of taxonomic use but Bowen (1957, p. 67, 68) stated: "While apertural variation may still be retained as a character useful in delimiting species on a purely morphological basis when fully described for all ontogenetic stages and in conjunction with several other biocharacters (as many as possible) it must be emphasized that alone, it is useless for generic determinations and even in association with other features has little taxonomic importance."

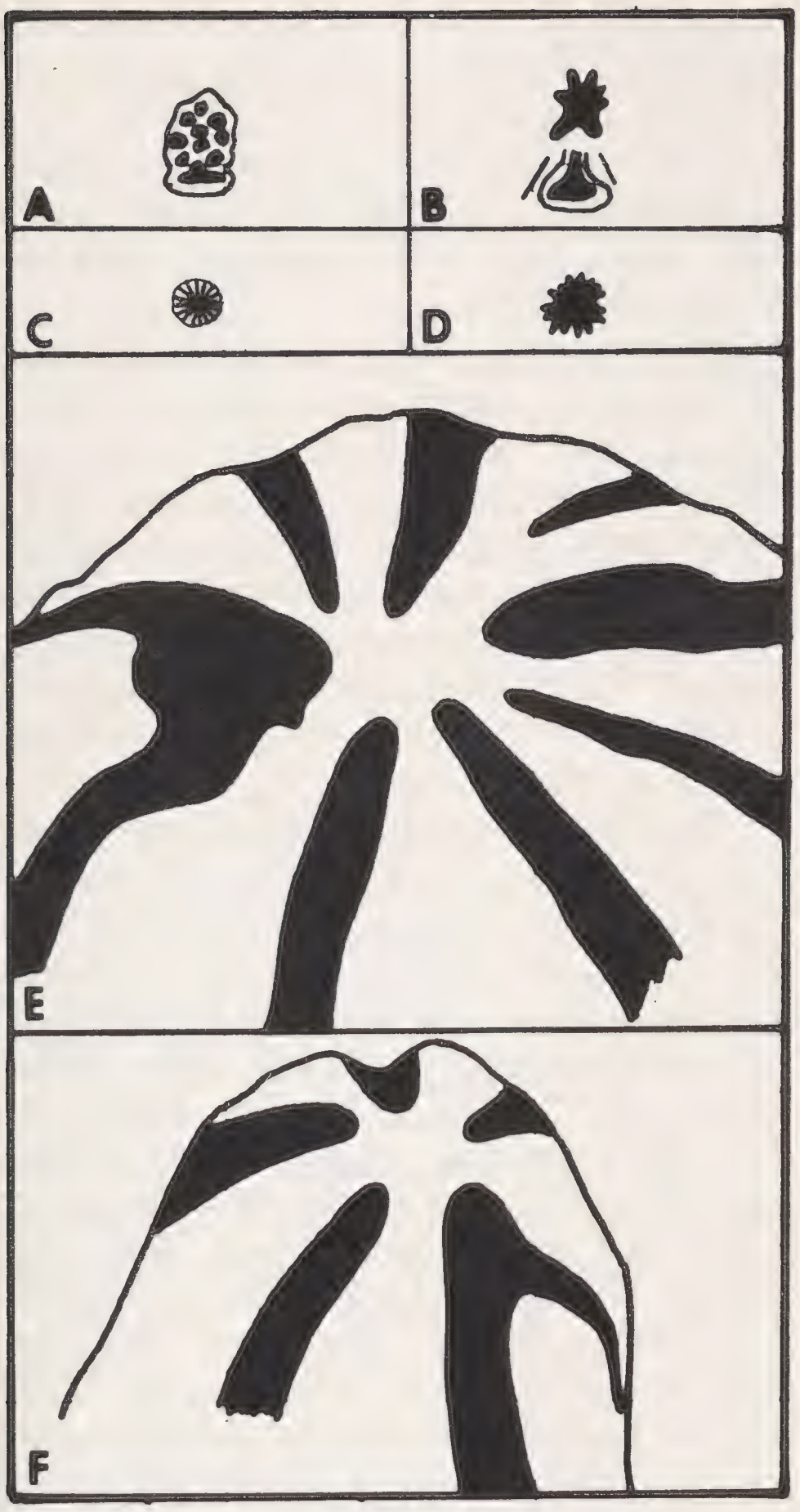
Boltovskoy and Wright (1976, p. 216) stated: "The long held view that the aperture is an invariate trait and that its position and character are constant, is no longer accepted."

A more moderate stand was taken by Orlov (1959), when he stated (p. 143, 144): "In establishing the systematical position of any genus, family, etc., it is to be established not from separate features (composition of wall, type of structure, character of aperture, etc.), but from an evaluation of the combination of these features. *At the same time the specific manifestation of one or another feature must be taken into account*" (present author's italics).

Pokorný (1958, p. 105) stated "the position and shape of the aperture is an important systematic feature," but qualified this statement (p. 166) with an analysis of parallel development between forms with a stable aperture throughout their phylogeny and forms that exhibit changes in the aperture during their phylogeny.

Fursenko (1959) regarded apertural configuration as a significant evolutionary feature and considered apertural types, such as radiate apertures, to be indicative of natural groups.

Loeblich and Tappan (1964a) accord apertural characters and modifications of them a level of importance higher than the category of chamber form and arrangement (p. C153). In the classification systematized by these authors in 1964(a) it is evident that



TEXT-FIGURE 1

A: Aperture of *Cribrorobulina serpens* Thalmann, 1947, indicating cribrate and slit-like components. Redrawn from original illustration (text-figure 2 x 100)

B: Aperture of *Cribrorobulina taustoma* Ruggieri and Pumo, 1964, illustrating inverted T shape component. Redrawn from original illustration (fig. 7 x 60).

C: Interpretation of a radiate aperture, after Boltovskoy and Wright (1976, fig. 32).

D: Interpretation of a radiate aperture, after Loeblich and Tappan (1964a, fig. 61, 2).

E: Interpretation of radiate aperture, after Murray, 1971, drawn from illustration of *Dentalina legumen* (Linné) (Pl. 30, fig. 2 x 480 approx.). Note central, solid, calcite structure.

F: Interpretation of radiate aperture, after Murray, 1971, drawn from illustration of *Dentalina subarcuata* (Montagu) (pl. 30, fig. 4 x 500 approx.). Note central, solid, calcite structure.

they accept generic distinction based on apertural characters alone, and not on these characters used in conjunction with any other morphocharacters. Their philosophy is well exemplified by their treatment of *Cribrobigenerina* Andersen, 1961; *Cribratina* Sample, 1932; *Cribrohantkenina* Thalmann, 1942; *Cruciloculina* d'Orbigny *in* de la Sagra, 1839; and *Cribropyrgo* Cushman and Bermúdez, 1946.

Haman (1972) erected the genus *Cribrospirolina* based on apertural character differentiation from *Spirolina* Lamarck, 1804, and further discussed and detailed this feature in 1976.

Kihle and Lofaldli (1975) illustrated *Sigmomorphina undulosa* (Terquem) from the Norwegian continental shelf. The illustrated specimen possessed a cribrate aperture but these authors did not comment on the feature.

Boltovskoy and Wright (1976) in their dismissal of any taxonomic value ascribed to the aperture, note that "certain genera exhibit different apertural arrangements under different environmental conditions" (p. 75). They did not conclude that all genera exhibit apertural modification as a result of phenotypic variation.

The same authors list (p. 216, 217) a number of published works that they claim substantiate their viewpoint of apertural variation having little if any taxonomic value. Eight of these articles refer to data published on fossil forms, and four are concerned with data obtained from Recent taxa, either by direct observation, or by culture methods.

Where apertural variation can be demonstrated to occur in a population of a specific Recent taxon, either through ecophenotypic variation or ontogenetic change, either by *in situ* observations or through culture methods the tenet of apertural variation having little or no taxonomic value must be followed. It

is, however, virtually impossible to prove such relationships with fossil taxa, and any conclusions along these lines must be regarded as interpretive and not absolute.

Consequently, all paleontologists are faced with a philosophical dichotomy. In the Recent, valid attempts can be made to relate taxa on a population basis, but when dealing with fossil forms the approach has to be more simplistic. The former category would approach the *gamma* taxonomy of Corliss (1962), which can be regarded as an attempt to synthesize data into a natural (or biological) hierarchy. The more simplistic approach with fossil forms can be referred to the *alpha* taxonomy of Corliss (1962), and any attempt to raise this taxonomy to a higher level would be based only on conjecture.

Frizzell and Schwartz (1950) in their taxonomic emendation of *Cribrostomoides* Cushman, 1910, based on apertural characters state: "The sporadic development of multiple apertures . . . is an example of phenomenon that we would call anticipation: the development of a morphological feature in a few members of a population, that if predominant would be given generic value." This statement complicates the issue in that the above authors indicate that the specific feature on which a taxon is differentiated does not achieve importance until forms exhibiting that particular feature become a significant component of a population. This philosophy can be somewhat subjective when dealing with Recent populations and even more so when dealing with fossil assemblages.

This author believes that it is preferable with fossil taxa to adopt a simplistic approach when dealing with a distinct morphocharacter. If fossil taxa can be morphologically differentiated either on the basis of a single distinctive feature or on a group of biocharacters, the forms should be separated either on a generic or specific level depending on the taxonomic significance of the particular feature. If additional work or new data can unquestionably, not subjectively, prove that these taxa are closely related or identical on a taxonomic or biologic basis the forms should then be accorded a different taxonomic treatment. However, if this treatment results in the grouping together of taxa, the treatment has to be based on absolute proof and not on speculation or inspired interpretation, otherwise the danger exists that many taxa will lose their potential stratigraphic value.

Further, this author acknowledges the philosophy of Frizzell and Schwartz (1950), quoted above, and believes that taxonomic differentiation based only on a few specimens could be premature, and that these specimens could represent simple ecophenotypic variants. The idea of these authors concerning the predominance in a sample is not followed, rather the concept of a consistent occurrence is preferred.

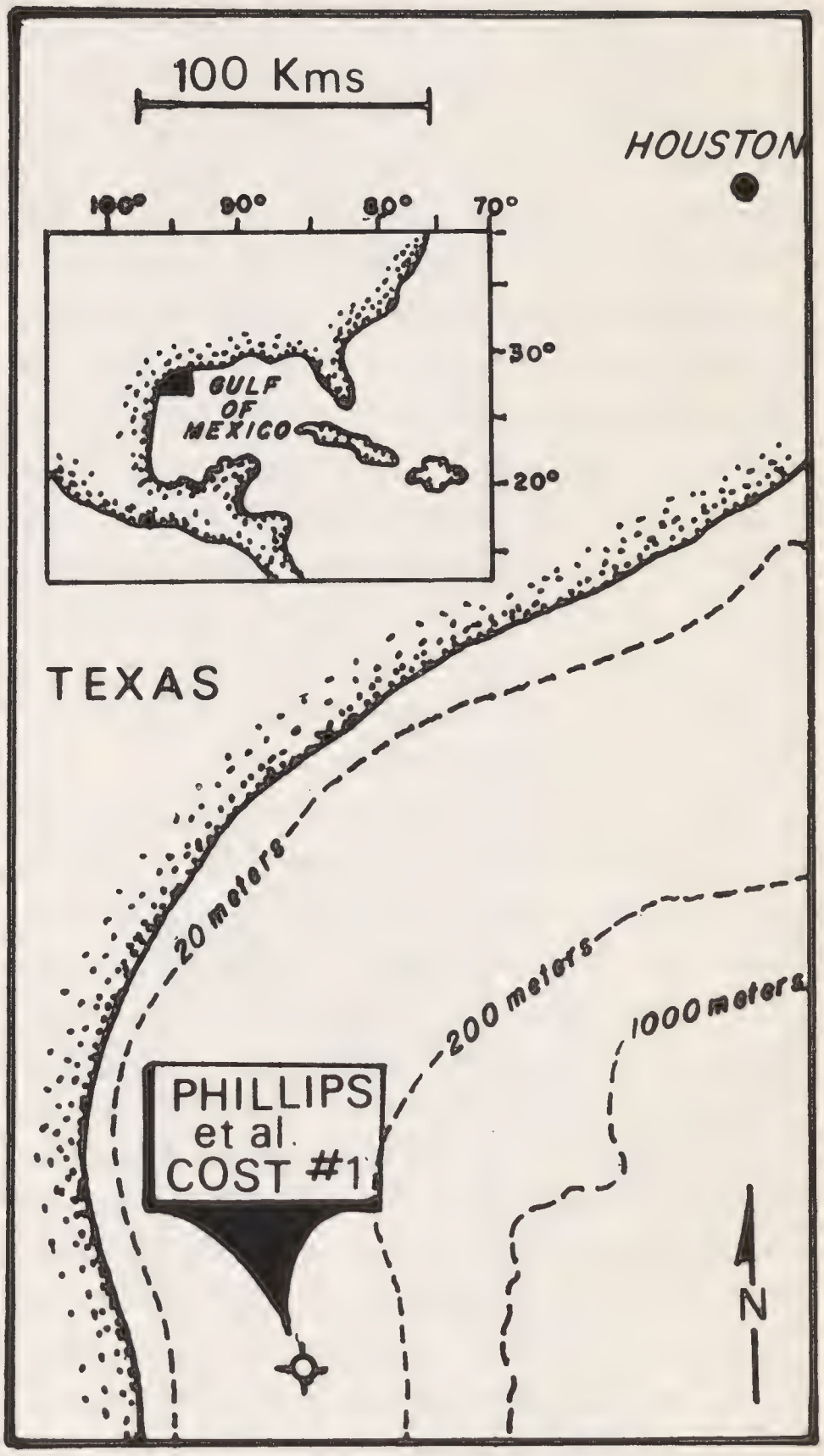
The importance of a specific biocharacter must be evaluated in terms of the taxonomic hierarchy. For example, test ornamentation is not accorded a high level of taxonomic validity and has been shown to be related to ecological parameters (Bandy, 1960, 1964; Pflum and Frerichs, 1976). The aperture is considered by this worker to be a biocharacter which has significant value in the taxonomic framework for the following reasons. The aperture is a feature by which a foraminifer exudes protoplasm for the purpose of nutrition, expulsion of waste matter, cyst and chamber formation, and in the case of benthic forms, for the purpose of locomotion and/or substrate attachment. Further, the aperture is an integral part of the test and the means by which gametes or embryos are released into the environmental milieu to further the existence of that particular taxon. Consequently, morphologic differentiation based on aperture characteristics or modifications of the aperture is believed taxonomically viable on a generic level.

B. THE *LENTICULINA* PLEXUS

The genus *Lenticulina* Lamarck, 1804, has, since validation, proved to be an anathema to micropaleontologists, when attempts have been made to establish the relationships between this genus and allied taxa. *Lenticulina* itself has proved to be problematic as is evidenced by the fact that Loeblich and Tappan (1964a) regard 29 described genera

as junior synonyms of this genus. Further, 14 of these synonomous genera were erected by one worker, Denys de Montfort, in a single work published in 1808. One of these genera, namely *Robulus* de Montfort, 1808, prior to being regarded as a junior synonym, created considerable taxonomic problems in its differentiation from *Lenticulina*. Orlov (1959) retained both of the above genera and differentiated them on the basis of apertural modification, in the case of *Robulus*, with a robuline slit, from the typical radiate aperture as shown by *Lenticulina*. Loeblich and Tappan (1964a) regard this modification as a gradational and not a distinct, constant feature.

Loeblich and Tappan (1964a) present a diagnosis of *Lenticulina* that appears uncomplicated on the surface. Their illustrations of this genus, however, (fig. 406; 1-8) show that considerable variation exists in the generic concept. In fact, they state (p. C520) ". . . in large assemblages of any species of this genus random asymmetrical, twinned, or even partially uncoiled specimens may be obtained." The same authors reiterated this view in the same year (Loeblich and Tappan, 1964b) when they stated (p. 26) ". . . some specimens of various *Lenticulina* species show asymmetrical or trochospiral coiling or uncoiling." On acceptance of the evidence that forms of *Lenticulina* can possess an uncoiled adult test, questions arise as to the relationship of *Vaginulinopsis* Silvestri, 1904, and *Marginulinopsis* Silvestri, 1904, to *Lenticulina* and indeed to each other. *Vaginulinopsis* and *Marginulinopsis* are basically determined as possessing an initial enrolled lenticuline stage that uncoils in the adult stage. The uncoiled portion of *Vaginulinopsis* is determined to be slightly compressed, as in *Vaginulina,* but *Marginulinopsis* has a rectilinear stage similar to *Marginulina* (Loeblich and Tappan, 1964a). The problematic relationships between *Lenticulina, Vaginulinopsis,* and *Marginulinopsis* have been commented on by many workers, for example, Cushman (1948). Orlov (1959) regarded the latter two taxa as subgenera of *Lenticulina* and stated (p. 253) "in typical forms *(Lenticulina* is) involute. . . in varieties it is uncoiled in late stages of orthogenesis." Putrya (1970), however, erected a new subfamily, Vaginulinopsinae, to accommodate the genera *Vaginulinopsis, Marginulinopsis,* and *Marginulina.*



TEXT FIGURE 2.

Location of Phillips *et al.,* Continental Offshore Stratigraphic Test (COST) #1.

Though *Lenticulina* is normally accepted as an enrolled, planispiral, involute form one must consider the already quoted statement of Loeblich and Tappan (1964a) regarding the degree of variation encountered in any species of this genus in large populations. The taxon *Lenticulina inusitatus* Cushman [= *Robulus gutticostatus* (Gümbel); = *R. gutticostatus* (Gümbel) var. *cocoaensis* (Cushman)] well exemplifies such variation.

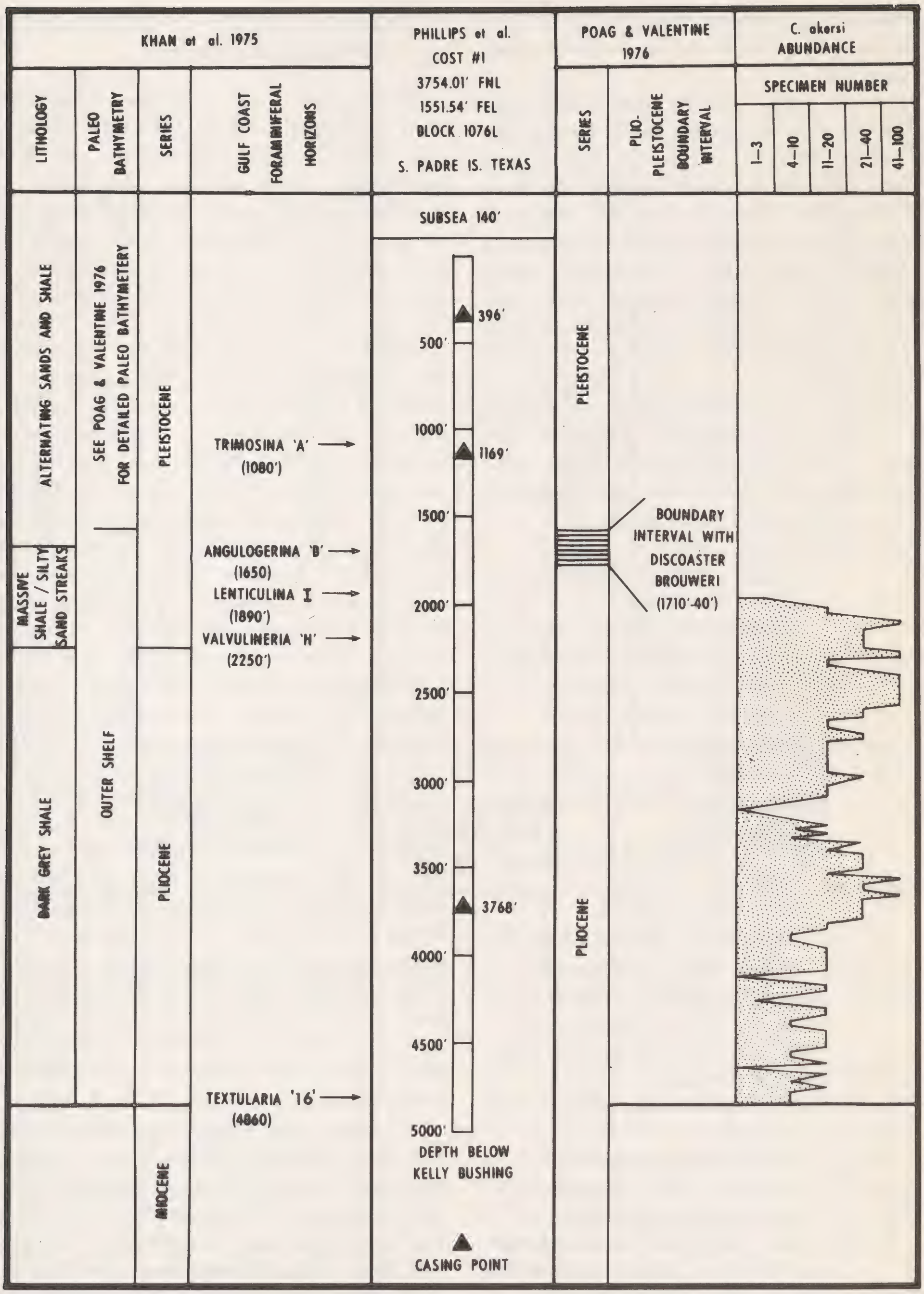
On the premise that *Lenticulina* does uncoil in the adult stage, the generic differentiation between this genus and *Vaginulinopsis* and *Marginulinopsis* and between these latter forms becomes somewhat suspect. The initial portion of *Vaginulinopsis* is similar to *Lenticulina (i.e.,* periphery angled or keeled) (Loeblich and Tappan 1964a) and that of *Marginulinopsis* is keeled or with an angular periphery. Lewis (1970, referring to p. C524 of Loeblich and Tappan 1964a) stated that *Vaginulinopsis* does not possess an initial angular periphery. No evidence has been noted to substantiate this observation and, consequently, the observations of Loeblich and Tappan (1964a) are followed.

Differentiation between *Vaginulinopsis* and *Marginulinopsis* has been based on the nature of the cross section of the adult portion of the test (see Lewis, 1970; Andersen, 1971). Loeblich and Tappan (1964a) mentioned that *Vaginulinopsis* has a slightly compressed adult stage but make no direct observations on the adult stage of *Marginulinopsis.* The simple accepted generic "split" is that *Vaginulinopsis* has an adult portion which is ovate in section (Lewis, 1970) or elliptical to slightly compressed (Andersen, 1971), but *Marginulinopsis* is circular to subcircular in cross section (Orlov, 1959).

It is believed by this author that *Vaginulinopsis* and *Marginulinopsis* represent end members of a population, the *Lenticulina* plexus, and that numerous gradational or transitional forms exist between them. These transitional forms are not readily assignable to any of the "genera." The entire plexus is believed to represent a single genus and the "generic" differentiation into *Vaginulinopsis* and *Marginulinopsis* based on degree and type of uncoiling in the adult stage is artificial and is simply the result of variation within the population. It is conceivable that these differences are in part related to the neanic, ephebic, and gerontic stages of ontogeny. The artificiality of the *Lenticulina* — *Vaginulinopsis* differentiation has been demonstrated by Bhalla and Abbas (1975) in their studies on *Lenticulina subalata* (Reuss) from the Jurassic of Kutch. These authors differentiated seven morphovariants of this species which, if taken separately, could be regarded as distinct species and possibly even different genera.

The genus *Saracenaria* Defrance *in* de Blainville, 1824, is diagnosed to be a form characterised as planispiral in the early stage with a later tendency to uncoil, the adult uncoiled test being triangular in cross section with a broad, flat, apertural face (Loeblich and Tappan 1964a). It is evident from a cursory examination of the entries in the Ellis and Messina *Catalogue of Foraminifera* (1940 *et seq.)* under the genera *Saracenaria* and *Vaginulinopsis* that numerous workers have experienced difficulty with the delimitation of these genera based on the external morphologic features. The forms with a narrow apertural face *(Vaginulinopsis* group) and the forms with a broad face and triangular test cross section *(Saracenaria* group) are readily distinguished, but there are innumerable transitional forms between these groups. The criteria of triangularity in cross section of an adult test *(Saracenaria)* as opposed to an ovate-compressed cross section *(Vaginulinopsis),* as well as the possession of a broad face as opposed to a narrow face, are believed artificial. This philosophy tends to agree with that of Glaessner (1945), who stated (p. 133) "... the validity of genera which are based only on the distinction between "curved" and "coiled" early growth, or generally on single uncorrelated features arbitrarily taken from gradational series, is doubtful." In this present article such artificial differentiation is not followed. As Tappan (1976) stated, "genetic variation may be continuous within a population so that all gradations may be seen between extreme limits."

Putrya (1970) erected the genus *Pravoslavlevia* to accommodate uncoiling lenticuline forms. These forms, however, have a distinct saracenarid affinity (p. 14, figs. 8-10). In fact, Putrya (1970) selected *Saracenaria pravoslavlevia* Fursenko and Polenova, 1950, as the genotype, but on the phylogenetic chart (fig. 1, p. 31) *Pravoslavlevia* is indicated to be an offshoot from the *Lenticulina* rootstock and is completely divorced from the *Saracenaria* lineage. It is



TEXT FIGURE 3

Biostratigraphic analysis of Phillips *et al.*, COST #1, offshore Texas (after Khan *et al.*, 1975, and Poag and Valentine, 1976) with *C. akersi* abundance indicated in Pliocene section.

believed that *Pravoslavlevia* is an accommodation of a transitional form and is herein disregarded.

In this article all the genera described above are referred to the genus *Lenticulina* on the premise that the former "genera" are based on artificial classificatory methods (archaetypical classification of Simpson, 1945) and are invalid when examined from a biological point of view. The terms 'vaginulinopsis' type, 'marginulinopsis' type, and 'saracenarid' type will be used in the descriptive morphology section in order to facilitate communication.

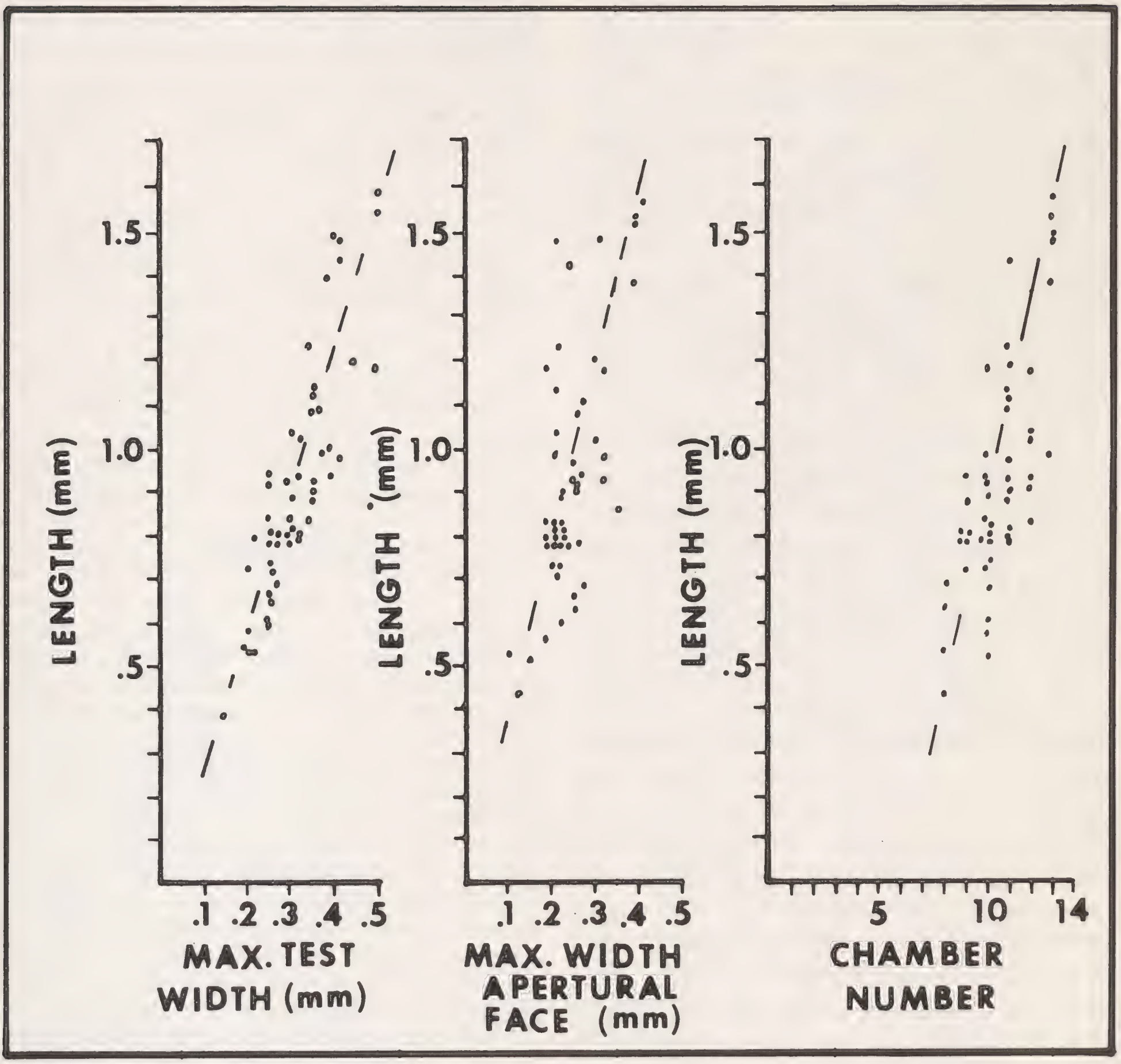
The following chronologic list synthesizes the numerous systematic categories and names now believed synonomous with *Lenticulina.* The list is in part abstracted from Loeblich and Tappan (1964a):

Lenticulina Lamarck, 1804 =
- Lamarck, 1804, *Lenticulites*
- de Montfort, 1808, *Antenor; Clisiphontes; Herion; Lampas; Linthuris; Macrodites, Oreas; Patrocles; Pharamum; Phonemus; Rhinocurus; Robulus; Scortimus; Sphincterules*
- Defrance *in* de Blainville, 1824, *Saracenaria*
- d'Orbigny, 1826, *Robulina, Soldania*
- Costa, 1856, *Nautilina*
- Stache, 1865, *Hemirobulina*
- Scudder, 1882, *Clisophontes*
- Sherborn, 1893, *Linthurus*
- Rzehak, 1895, *Cristellariopsis*
- Silvestri, 1904, *Marginulinopsis, Vaginulinopsis*
- Howe and Wallace, 1932, *Darbyella*
- Franke, 1936, *Saracenella*
- Wedekind, 1937, *Perisphincta*
- Wick, 1939, *Perisphinctina*
- Marie, 1941, *Enantiocristellaria*
- de Witt Puyt, 1941, *Hydromylina*
- Perebaskine, 1946, *Rimalina*
- Payard, 1947, *Eoflabellina*
- Harris and Sutherland, 1954, *Darbyellina*
- Putrya, 1970, *Pravoslavlevia*

C. *CRIBRO*ROBULINA – *CRIBROLENTICULINA* RELATIONSHIP

The genus *Cribrorobulina* Thalmann, 1947, was diagnosed by Loeblich and Tappan (1964a, p. C516), as having a test "like *Lenticulina,* but aperture consisting of numerous small round openings instead of being radiate." Thalmann, 1947, published an unambiguous type species description to accord validity to the genus *Cribrorobulina* first described by Selli in 1941. Though Loeblich and Tappan (1964a) reproduced the figures of *Cribrorobulina serpens* as emended by Selli (1941), they did not fully describe the aperture as detailed by that worker. Loeblich and Tappan (1964a) did not describe the "T rovesciata," as detailed by Selli (1941), although this feature is evident in the original type figures and in their reproduction of these figures (fig. 403, 1a, 1b, p. C515). Consequently, a simple diagnosis of *Cribrorobulina* should be expanded to read "Test like *Lenticulina* but aperture consisting of numerous small round openings below which may be surrounded by a lip. A vertical slit extends from the center of this transverse slit up into the grouping or cluster of pores that form the cribrate aperture." (Text-fig. 1A). This type of aperture is well illustrated by Selli (1941, text fig. 1, text fig. 2). The inverted T type of apertural modification was illustrated by Ruggieri and Pumo (1964) with their description of *C. taustoma* from the upper Oligocene of S.E. Sicily (Text-fig. 1B). This illustrated specimen does not possess the typical cribrate aperture above the transverse and vertical slits, as shown by *C. serpens* but is radiate in nature.

Loeblich and Tappan (1964a, p. C63) defined a radiate aperture as an "opening associated with numerous diverging slits" and illustrated the feature (fig. 61-2) (Text-fig. 1D). Boltovskoy and Wright (1976, fig. 32) illustrated an identical concept (Text-fig. 1C). Murray (1971, p. 75) stated "the general concept of a radiate aperture is that it is a series of intersecting slits arranged in a radial fashion." He further stated that "in detail the aperture is made up of radial, elon-



TEXT FIGURE 4

Data plot, length-width; length-maximum width of apertural face; length-chamber number of 50+ specimens of *C. akersi* from the Pliocene section of the Phillips COST #1 offshore Texas.

gate slits but . . . they do not intersect. Thus, the center of the aperture region is a solid calcite structure." (Text-fig. 1E,F). It is believed possible that numerous forms described as possessing radiate apertures *(sensu* Loeblich and Tappan, 1964a and others) may, in fact, represent apertures that have been broken or damaged with the result that the central calcite structure described by Murray (1971) has been destroyed. *C. taustoma,* mentioned above, may fail in this category.

Difficulties have been encountered by various workers in the correct interpretation of the term "cribrate." This problem was reviewed by Haman (1972). Again, it is believed possible that if the central portion of a cribrate aperture were to be destroyed the remainder of the aperture would assume a "pseudo-radiate" appearance. This will be demonstrated below in the analysis of *Cribrolenticulina.*

Cribrolenticulina can be differentiated from *Cribrorobulina* on the nature of the aperture. Though *Cribrorobulina* has a cribrate aperture, complicated by the transverse and vertical slits, *Cribrolenticulina* possesses a typical cribrate aperture.

D. SAMPLE LOCALITY

Representatives of the new genus *Cribrolenticulina* were obtained from rotary cutting samples taken during the drilling of the Continental Offshore Stratigraphic Test (COST) No. 1 well in November, 1974. This stratigraphic test, financed by a combine of 33 oil and gas companies with Phillips Petroleum Company as operator, was drilled in Block 1076-L of the East Addition of the South Padre Island area, offshore Texas, (Text-fig. 2).

Khan *et al.* (1975) published a biostratigraphic analysis of this well based on the rotary samples. Poag and Valentine (1976) utilized data from the upper portion of the stratigraphic well in their synthesis of the Pleistocene depocenter of the Texas-Louisiana continental shelf, (Text-fig. 3).

The position of the Plio-Pleistocene boundary in the test well is open to interpretation as evidenced by the studies mentioned above. Khan *et al.* (1975) place this boundary at 2,550 feet based on the downhole appearance of the *Valvulineria* "H" fauna. Poag and Valentine (1976) did not pick a precise point for the boundary location between the two series but preferred to pick a "boundary interval," which they stated (p. 188) "contains the boundary between the Pliocene and the Pleistocene." The top of this boundary interval is coincident with the top of the *Globigerina incisa* Bronnimann and Resig Partial Range Zone of Poag and Valentine (1976) and is placed at 1,565 feet below the Kelly Drive Bushing. The boundary interval extends for 200 feet below this point and includes the extinction of *Discoaster brouweri* Tan Sin Hok at 1,710-1,740 feet below the Kelly Drive Bushing (Poag and Valentine, 1976). The stratigraphic terminology of Poag and Valentine (1976) is followed in this article with regard to the Pliocene and Pleistocene, and Khan *et al.* (1975) is followed for placement of the Miocene-Pliocene boundary, lithologic descriptions and paleobathymetric interpretations. Text-figure 3 illustrates the different stratigraphic concepts, indicates the lithologic and environmental analyses, and shows the relative abundance of *Cribrolenticulina* from its first appearance downsection in the well to the top of the Miocene (based on the first downsection occurrence of *Textularia "16"* by Khan *et al.*, 1975).

IV. SYSTEMATIC PALEONTOLOGY

Class RHIZOPODEA von Siebold, 1845
Order FORAMINIFERIDA Eichwald, 1830
Suborder ROTALIINA
Delage and Herouard, 1896
Superfamily NODOSARIACEA
Ehrenberg, 1838
Family NODOSARIIDAE Ehrenberg, 1838
Subfamily NODOSARIINAE
Ehrenberg, 1838
Genus CRIBROLENTICULINA Haman,
gen. nov.

Description: Test free, initially planispiral, lenticular, biumbonate, slightly compressed, periphery acute or keeled, later may be uncoiling; uncoiled test may be compressed (vaginulinopsis type) with an ovate to sub-ovate cross section, or non-compressed, flaring (saracenarid) with a triangular cross section; apertural face variable, narrow to broad; sutures curved; ornamented with tubercles on initial portion of test, in adult portion ornamented with elongate nodes which may become very attenuated; calcite bars may be present on some sutures in the adult test; aperture terminal, at end of prolongation of ultimate chamber, cribrate, at the peripheral margin; aperture may be affected by chemical and/or mechanical processes, or both, resulting in solution effects or breakage being evident; cribrate aperture restricted to ultimate chamber; wall calcareous, hyaline, perforate.

Type Species: Cribrolenticulina akersi Haman, *n. sp.*

CRIBROLENTICULINA AKERSI
Haman, n. sp.
Pl. 1, figs. A-X, Pl. 2, figs. A-S,
Pl. 3, figs. A-N, Pl. 4, figs. A-S.

Description: Test free, calcareous, hyaline, finely perforate, variable in size (Text-fig. 4), initially planispiral, test becoming uncoiled in adult, initial portion biumbonate, lenticular with an acute periphery, possibly possessing keel; adult portion may be compressed, thin, to slightly less compressed, or non-compressed, flaring so that adult test in cross section is elongate-ovate to ovate or triangular in shape; apertural face varying from long and narrow to broad and wide; apertural face width increasing with test length (Text-fig. 4); tests showing an increase in width with an increase in

length (Text-fig. 4); chambers ranging in number from eight to thirteen, chamber number increasing with increase in text length (Text-fig. 4), and in test width (Text-fig. 5), ultimate chamber exhibiting attenuation towards the aperture, which is situated at the end of the chamber prolongation at the peripheral angle; sutures curved, indistinct, obscured by ornamentation; ornamentation variable, restricted to sutural areas, with distinct ornament types on specific portions of the test; sutures on initial portion of test ornamented with elongate, parallel sided, circular in cross section, tubercles (Pl. 2, fig. L); size of tubercles reasonably uniform on each specimen but variable between specimens; suture ornamentation on adult portion of test composed of differing types, not all necessarily present on a single specimen; some specimens exhibiting a ridge or bar lying along the suture line near the umbonal area, bar extending only part way along the suture; towards periphery the bar is replaced by elongate nodes, aligned parallel or subparallel to the periphery; sutural nodes may only be slightly elongate to highly elongate, teardrop shaped; elongate nodes wider towards umbilicus, becoming narrower towards the aperture; elongation most distinct near the periphery where the nodes become highly attenuated on many specimens; the degree of uncoiling of the adult test reflected in the degree of node attenuation; aperture terminal, cribrate, situated at end of prolongation of ultimate chamber, prolongation strongly emphasized in vaginulinopsis types, less so in saracenarid types; at peripheral angle; apertural area not restricted to the top of the chamber prolongation but extending down the sides of the prolongation giving the apertural area a "pin cushion" appearance; aperture ranging in size from .08 mm to .13 mm; the component openings of the cribrate aperture basically circular but on tests examined (over 50) these openings have been affected, either chemically, mechanically, or through a combination of both processes; solution effects resulting in regular or irregular elongation and enlargement of the circular openings and often coalescence of adjacent openings; mechanical effects resulting in the apertures illustrating various degrees of destruction ranging from minimal to extreme in which the central portion of the cribrate aperture has been broken out leaving only peripheral openings giving a "pseudo-radiate" appearance to the aperture; cribrate aperture restricted to ultimate chamber, the previous chambers having no trace of this type of aperture; earlier apertures "pseudo-radiate" or simple circular openings.

Dimensions: Length (max.) 1.60 mm. Width (max.) 0.50 mm.

Type Level and Locality: Holotype: Rotary cuttings sample, 2,250-2,280 feet Phillips *et al.*, COST #1, South Padre Island area, offshore Texas; Pliocene.

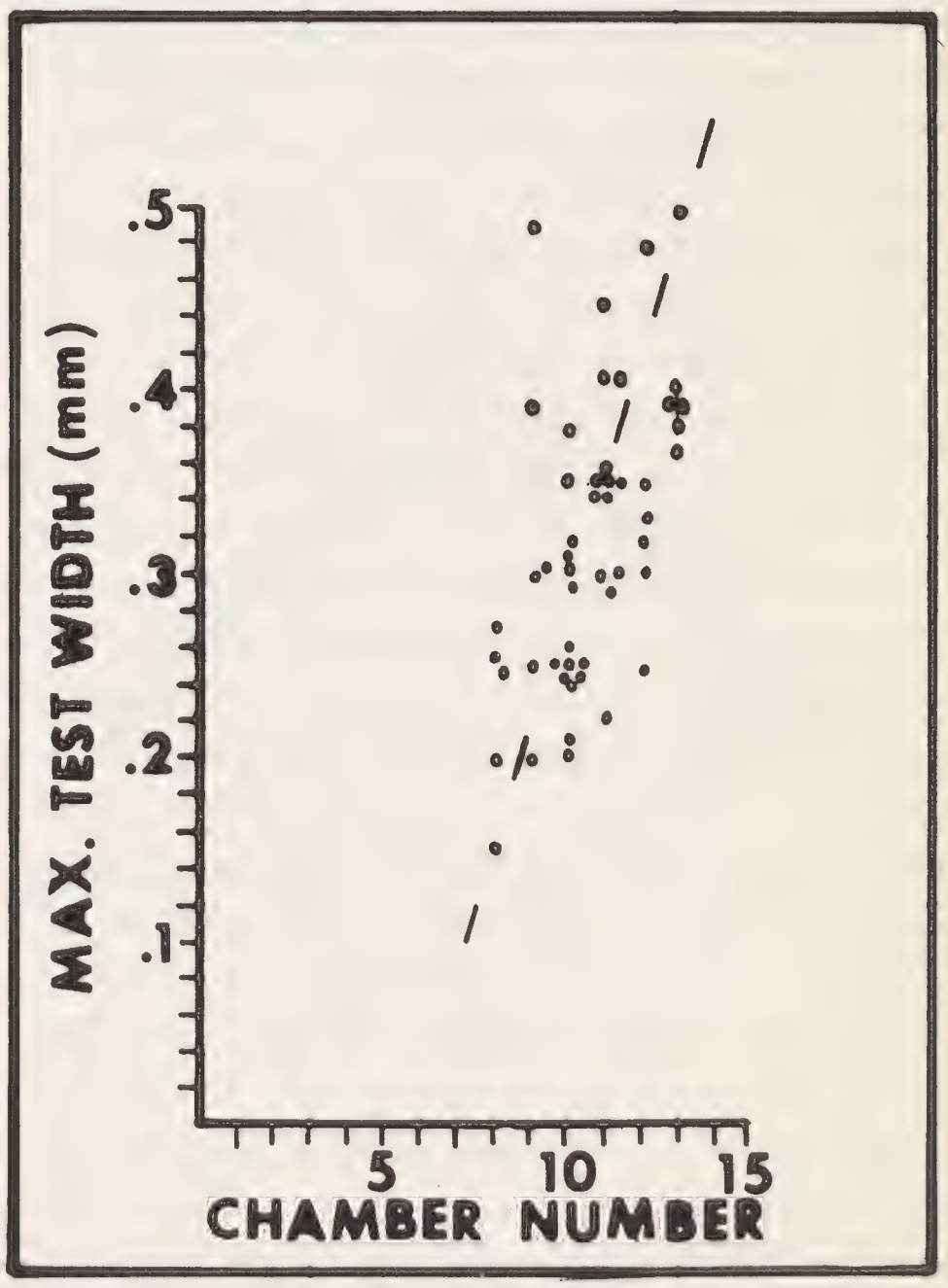
Paratypes: Rotary cutting samples, 1,980-4,860 feet, same well, Pliocene.

Depository: Holotype and paratypes are deposited in the U.S. National Museum (holotype USNM 247877, paratypes USNM 247878-247880) other paratypes are deposited in the Collection of Chevron U.S.A. Inc., Eastern Region and in the author's collection.

Nomino derivos: Species is named in honor of Dr. W. H. Akers (Chevron U.S.A. Inc., and Tulane University) for his exemplary contributions to the study of foraminifera.

Remarks: This species possesses a distinct cribrate aperture, which is highly variable between specimens as a result of chemical and mechanical processes. It is believed that some of these processes may have taken place during life but it is also believed that some of the changes are diagenetic in nature.

As was stated in the type description above, the component openings of the cribrate aperture are basically circular (pl. 2, figs. P,S.) in nature, but in numerous cases later modifications have affected this pattern. The chemical effects appear to be



TEXT FIGURE 5

Data plot, maximum test width – chamber number of 50+ specimens of *C. akersi* from the Pliocene section of the Phillips COST #1, offshore Texas.

mainly associated with solution which result in the circular openings becoming enlarged (pl. 2, fig. Q), irregular (pl. 4, fig. L) or coalesced (pl. 3, fig. I) in many cases. At the margin of the apertural region the coalescence of adjacent openings allows the aperture to assume a somewhat radial appearance as the coalescence takes place in a linear nature running from the edge of the aperture towards the center (pl. 3, fig. A). This feature is not truly radiate *(sensu* Murray 1971) as none of the tests examined show this linear coalescence all the way to the center of the apertural region. Where solution effects are severe with the coalescence of a number of pores the resultant opening could be mistaken for mechanical erosion, but it can be distinguished by a smooth, sinuous margin (pl. 3, fig. I) rather than a sharper margin (pl. 4, fig. J). Some specimens exhibit both types of openings (pl. 4, fig. F). Though some of the solution effects are believed diagenetic, some are believed to occur during life, in particular during the reproductive stage (Text-fig. 6). The breakdown of the cribrate aperture, or the enlargement of the openings during schizogony would be required to allow release of embryo gametes into the environmental milieu during the asexual reproductive phase (Text-fig. 6C). The degeneration of the cribrate aperture is not present in earlier chambers but is only present on the ultimate chamber. Protoplasm movement within the test could also possibly result in the resorption of these earlier cribrate apertures. It is not believed that an enlargement of the component openings would be required during gamogony to accommodate the gamete release (Text-fig. 6B). Mechanical or physical breakdown of this aperture can be minor (pl. 4, fig. H) ranging to major (pl. 3, fig. K). Large openings resultant of this process can be recognized by the sharp margins to the breaks, and their general angularity in shape (pl. 3, fig. B). When such breakage is of a major nature vestigial traces of the original cribrate aperture can still be noted, but in a few extreme cases almost all the cribrate portion of the aperture is destroyed (pl. 4, fig. J), and only very peripheral openings remain visible (pl. 4, fig. R). These peripheral remains have, as a result of allied solution, assumed a linear coalescence so that the aperture assumes a pseudo-radiate appearance (pl. 3, fig. J). Careful examination of these peripheral openings will, however, indicate faint traces of the original circular openings which have become coalesced. The original opening trace can be noted by a slight narrowing or constriction of the otherwise linear arrangement (pl. 3, fig. M). This feature can be readily recognized with a scanning electron microscope but is very difficult to observe with a light microscope as these constrictions are at or beyond the limits of resolution. It is this feature, the erosion of the central portion of the aperture, with only peripheral lineations visible, that has lead this author to the conclusion that it is quite possible that many "lenticuline" taxa described as possessing a radiate aperture may, in fact, actually possess an eroded cribrate aperture. Detailed examination of these apertures is necessary to determine their true nature.

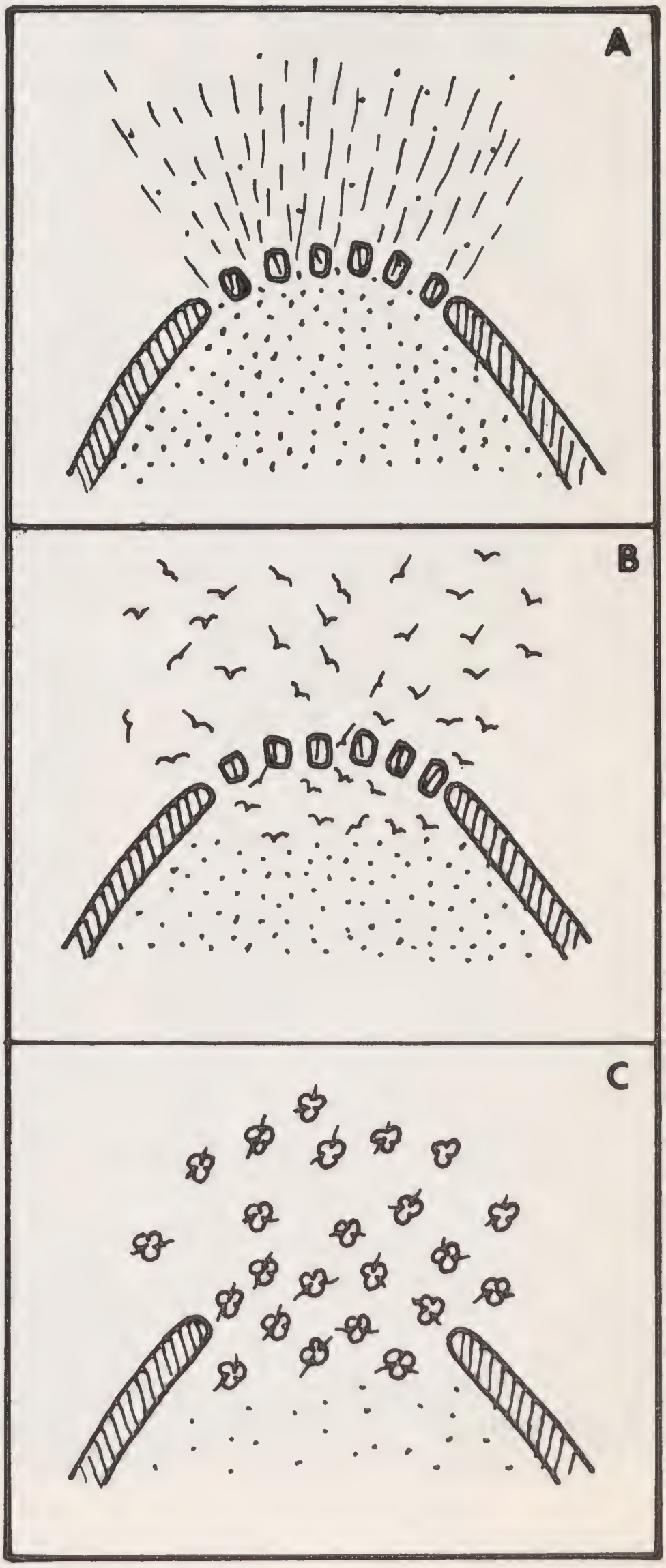
Pokorný (1958) has suggested that a cribrate aperture may be developed by the formation of cross-beams between the rays of a radial aperture or simply due to primary multiplication. The "cross-beam" hypothesis is not ascribed to by the present author.

It has been suggested that the cribrate aperture is a phylogenetic development from a true radiate aperture (Dr. F. T. Banner, pers. comm., 14 June 1976). Consequently, these described forms would represent an advanced taxon. Conversely this type of aperture may be the result of ecophenotypic variation in response to environmental parameters. Further studies are required to clarify the above hypotheses, but, irrespective of which theory is correct, taxonomic distinction is believed valid. While the functional morphology of the cribrate aperture is not known, it has been further suggested that it may represent a filter apparatus for food detritus incorporated by extruded protoplasm (Dr. F. T. Banner, pers. comm., 14 June 1976). The cribrate aperture has also been suggested to represent a

defensive adaptation (B. L. Hill, pers. comm., 18 Feb., 1977).

Test ornamentation has been described above, but it should be emphasized that the ornamentation is basically similar in all the specimens examined, namely, distinct tubercles on the initial portion of the test and more attenuated nodes on the adult portion. The degree of ornament attenuation in the adult test appears to be the variable feature between specimens. Some forms exhibit minor attenuation (pl. 1, fig. W), but others show marked attenuation (pl. 1, fig. O). In all cases, however, this degree of attenuation increases away from the apertural face towards the periphery (pl. 1, fig. I). The other variable ornamentation feature is that of the transverse bars lying along the sutures of the adult test. Some forms possess these bars (pl. 2, fig. N), some do not (pl. 1, fig. I), and others exhibit modifications of the bar (pl. 1, fig. S). The main modification to the bars appears to be in the nature of a discontinuous alignment of nodes. This variation in ornamentation is not accorded significant taxonomic validity. A wide range of variation in test morphology is illustrated by *C. akersi.* Specimens within this range could conceivably be regarded as separate species and, with the end members, even different genera, the vaginulinopsis and saracenarid types. The philosophy adopted with this taxon, however, follows that detailed earlier in this article with regard to the *Lenticulina* plexus. It is believed that all the illustrated forms belong to the single biologic genus *Cribrolenticulina* and to the single species *C. akersi.*

For the reasons mentioned above pertaining to problems with the recognition of the correct type of aperture, *i.e.*, eroded cribrate or radiate, affinities to other described lenticuline taxa are difficult to determine. Forms which may be related to this new genus are listed below. The list is conjecture only due to the lack of reliable information on the nature of the aperture. Forms listed below are listed with their original taxo-



TEXT FIGURE 6

Schematic illustrations of the aperture of *C. akersi* at various stages during the life cycle.

A: Normal protoplasmic streaming through intact cribrate aperture.

B: Release of flagellate gametes during gamogony. Gametes released through openings in intact cribrate aperture.

C: Release of embryo gametes during schizogomy. Gametes released through large openings in aperture as a result of cribration breakdown.

nomic terminology: *Cristellaria gemmata* Brady, 1881; *C. granosa* Hantken, 1871; *C. mexicana* Cushman, 1925; *C. vaughani* Cushman, 1918; *Hemicristellaria sumatrica* LeRoy, 1944; *Lenticulina cibaoensis* Bermúdez, 1949; *L. cristobalensis* Bermúdez, 1949; *L. guttata* (ten Dam) *striata* Bartenstein and Brand, 1951; *L. hanseni* Garrett, 1942; *L. yaguatensis* Bermúdez, 1949; *Marginulina longicollis* Bermúdez. 1949; *M. superba* Cushman and Renz, 1941; *M. toulmini* Cushman, 1944; *Robulus hoppoensis* Nakamura, 1937; *R. lacerta* Garrett, 1939; *R. senni* Cushman and Renz, 1941; *Saracenaria toddae* Bermúdez, 1949; *Vaginulina awaensis* Asano, 1938; *Vaginulinopsis baggi* McLean, 1955. The above list is not exhaustive but indicates some forms that may yield worthwhile information on the aperture when examined with a scanning electron microscope.

Skinner (1963) described *Lenticulina (Robulus) cristi* from the middle Miocene of Lafourche and Iberia Parish in southern Louisiana. This form shows very significant affinities to *Cribrolenticulina akersi* in overall test arrangement and ornamentation. *L. cristi* was stated to possess an aperture that is "elevated, radiate, distinctly robuline with an elongate slit in the median line extending into the apertural face." (Skinner, 1963, p. 150). Skinner and Steinkraus *in* Skinner (1972) illustrated by means of scanning electron microscope photographs of paratypes of *L. cristi.* These photographs indicate some disparity with the type description of the species by Skinner (1963) in the nature of the aperture. Skinner and Steinkraus *in* Skinner (1972) reiterate the description of the aperture given by Skinner (1963) and indicate this robuline aperture to be present in a line drawing of the holotype re-illustrated in

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PLATE 1

Figures A-X *Cribrolenticulina akersi* Haman, from the Phillips *et al.,* COST #1 well, offshore Texas.

A, B; Paratype, sample 2010'-2040'; A: side view x 62; B: front view x 63 (specimen no. 16).

C, D; Paratype, sample 2070'-2100'; C: side view x 34; D: front view x 31 (specimen no. 26).

E, F; Paratype; sample 2250'-2280'; E: side view x 60; F: front view x 57 (specimen no. 42).

G, H; Paratype; sample 2250'-2280'; G: side view x 44; H: front view x 47 (specimen no. 40).

I, J; **Holotype**; sample 2250'-2280'; I: side view x 50; J: front view x 45 (specimen no. 50).

K, L; Paratype; sample 2250'-2280'; K: side view x 30; L: front view x 29 (specimen no. 37).

M, N; Paratype; sample 2040'-2070'; M: side view x 42; N: front view x 35 (specimen no. 22).

O, P; Paratype; sample 2250'-2280'; side view x 40; P: front view x 39 (specimen no. 44).

Q, R; Paratype; sample 2250'-2280'; Q: side view x 47; R: front view x 49 (specimen no. 51).

S, T; Paratype; sample 2070'-2100'; S: side view x 48; T: front view x 46 (specimen no. 30).

U, V; Paratype; sample 2010'-2040'; U: side view x 60; V: front view x 56 (specimen no. 14).

W, X; Paratype; sample 2010'-2040'; W: side view x 58; X: front view x 55 (specimen no. 19).

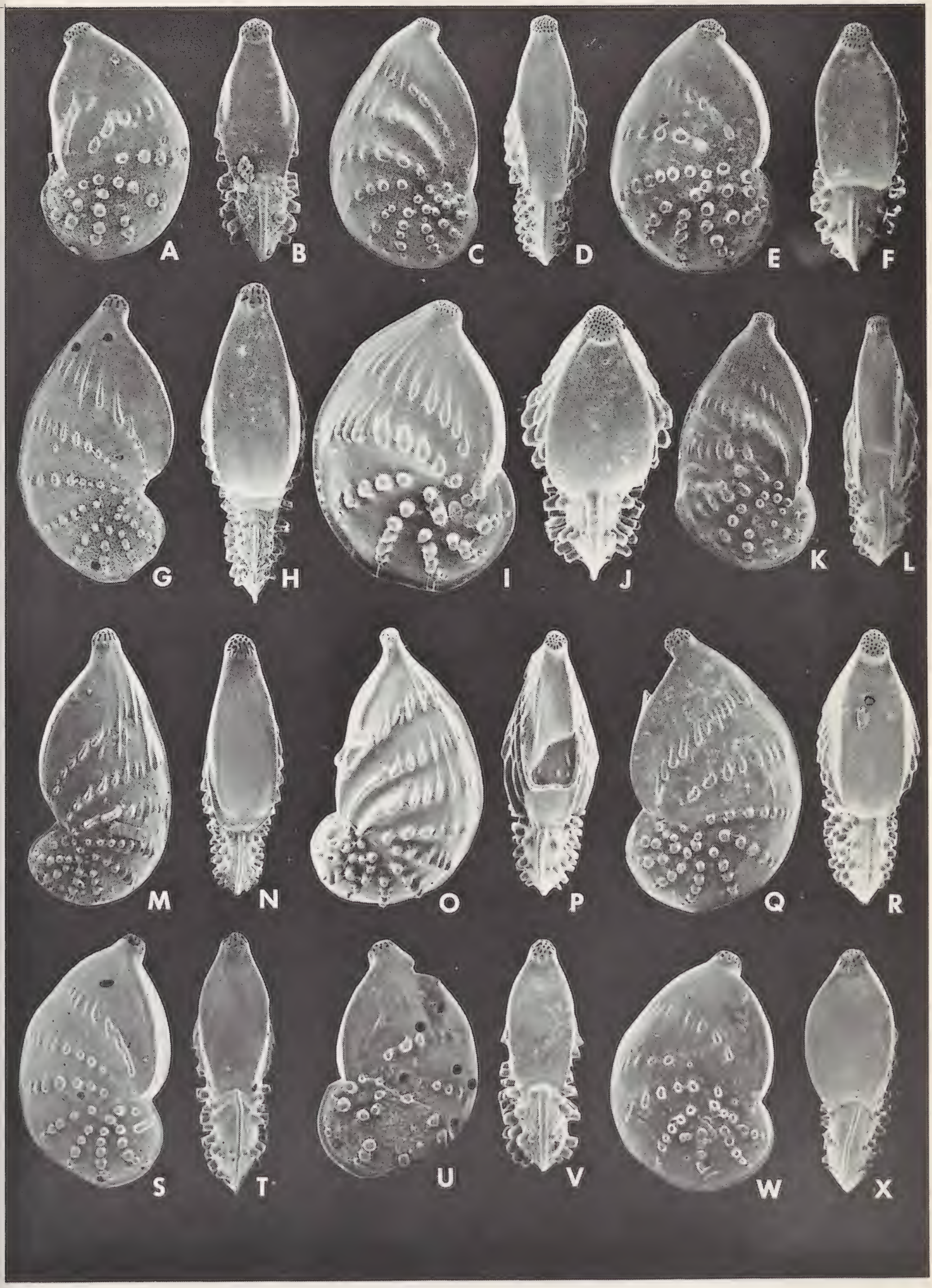

PLATE 1

the 1972 article. The photographs (SEM) of *L. cristi* in the 1972 publication however, do not show any trace of the robuline slit. Examination of the holotype of *L. (R.) cristi* Skinner (USNM 640982) indicated that the aperture is radiate in nature without any trace of a cribrate or eroded cribrate aperture. Further, the elongate slit in the median line below the aperture as described by Skinner (1963) is not evident.

All the described and illustrated specimens detailed in this article are from the Texas COST #1 well. Specimens related to the *C. akersi* plexus have been recorded from Pliocene beds at an outcrop 4.5 km south of Acayucan, Vera Cruz, Mexico (B. Kohl, pers. comm.). Consequently, this species appears to have a wide geographic distribution in the Gulf of Mexico province during the Pliocene.

V. ACKNOWLEDGMENTS

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PLATE 2

Figures A-S; *Cribrolenticulina akersi* Haman, from the Phillips *et al.*, COST #1 well, offshore Texas.

A, B; Paratype; sample 2010'-2040'; A: side view x 48; B: front view x 45 (specimen no. 17).

C, D; Paratype; sample 2070'-2100'; C: side view x 27; D: front view x 28 (specimen no. 3).

E, F; Paratype; sample 2250'-2280'; E: side view x 46; F: front view x 46 (specimen no. 38).

G, H; Paratype; sample 2070'-2100'; G: side view x 48; H: front view x 40 (specimen no. 27).

I; Paratype; sample 3690'-3720'; oblique side view x 21 (specimen no. 19).

J; Paratype; sample 2250'-2280'; front view showing "pseudo-radiate" aperture x 47 (specimen no. 45).

K; Paratype; sample 2070'-2100'; oblique front view x 48 (specimen no. 4).

L; Enlargement of initial portion of holotype test to illustrate tubercle development, length of field 0.18 mm. (specimen no. 50).

M, N; Paratype; sample 2250'-2280'; M: front view x 44; N: side view x 44. (specimen no. 41).

O; Paratype; sample 2010'-2040'; oblique front view x 77 (specimen no. 18).

P; Aperture of paratype no. 42, sample 2250'-2280'; max. diam. 0.08 mm.

Q; Aperture of paratype no. 43, sample 2250'-2280'; max. diam. 0.09 mm.

R; Aperture of paratype no. 34, sample 2250'-2280'; max. diam. 0.09 mm.

S; Aperture of paratype no. 26, sample 2070'-2100'; max. diam. 0.12 mm.

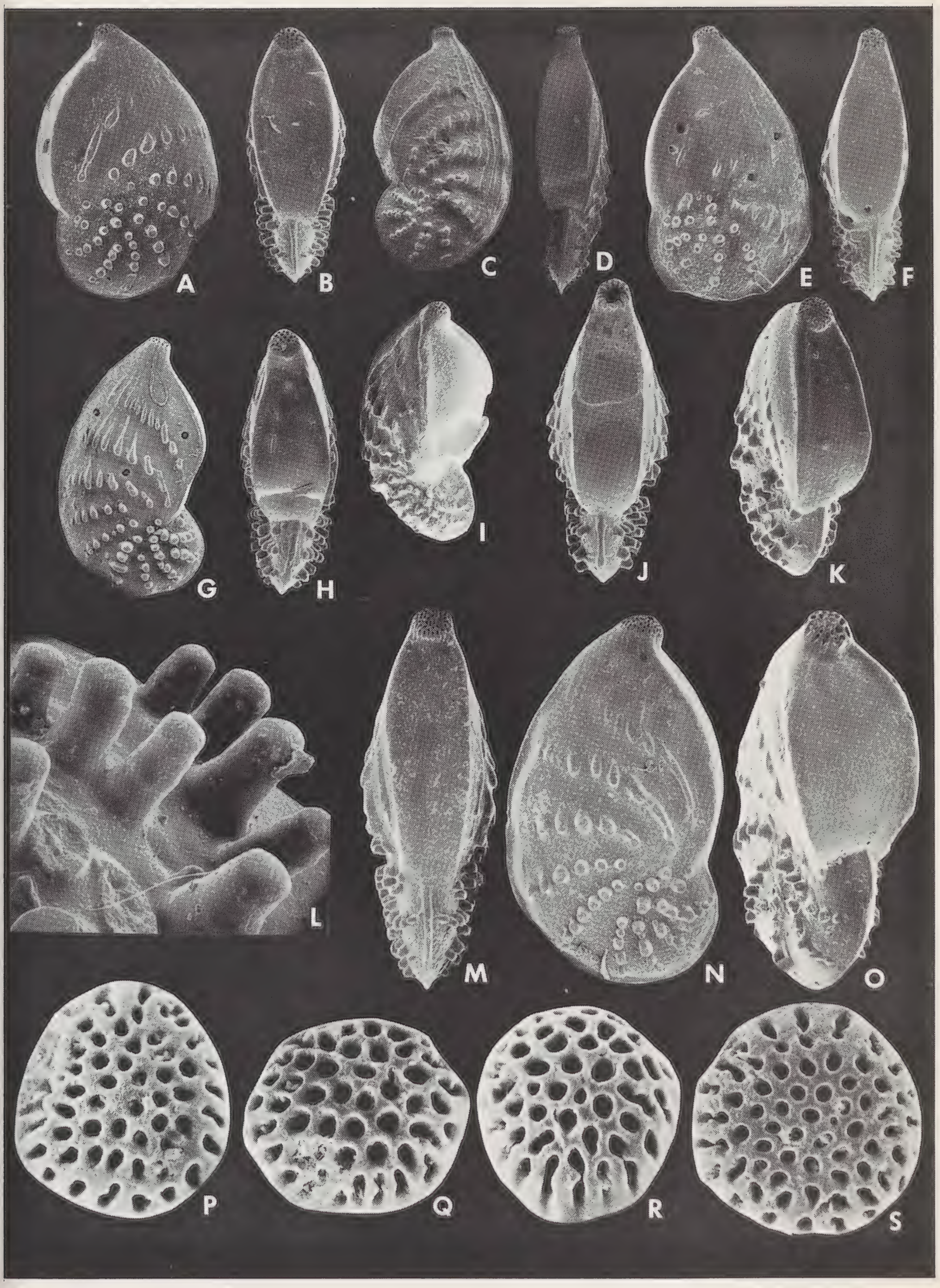

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PLATE 3

Figures A-N: Apertures of *Cribrolenticulina akersi* Haman, from the Phillips *et al.*, COST #1 well, offshore Texas.

A; Paratype no. 23, sample 2070'-2100'; max. diam. 0.10 mm.

B; Paratype no. 30, sample 2070'-2100'; max. diam. 0.09 mm.

C; Paratype no. 19, sample 2010'-2040'; max. diam. 0.09 mm.

D; Paratype no. 15, sample 2010'-2040'; max. diam. 0.09 mm.

E; Paratype no. 32, sample 2070'-2100'; max. diam. 0.09 mm.

F; Paratype no. 18, sample 2010'-2040'; max. diam. 0.09 mm.

G; Paratype no. 35, sample 2250'-2280'; max. diam. 0.10 mm.
Arrow indicates the coalescence of two adjacent openings.

H; Paratype no. 45, sample 2250'-2280'; max. diam. 0.10 mm.

I; Paratype no. 36, sample 2250'-2280'; max. diam. 0.10 mm.
Arrow indicates sinuous margin resultant of the coalescence of a number of the original component openings.

J; Paratype no. 8, sample 3450'-3480'; max. diam. 0.10 mm.

K; Paratype no. 33, sample 2070'-2100'; max. diam. 0.09 mm.

L; Paratype no. 16, sample 2010'-2040'; max. diam. 0.08 mm.

M; Paratype no. 22, sample 2040'-2070'; max. diam. 0.11 mm.
Arrow indicates constriction in linear opening indicative of coalescence of adjacent openings.

N; Paratype no. 40, sample 2250'-2280'; max. diam. 0.09 mm.

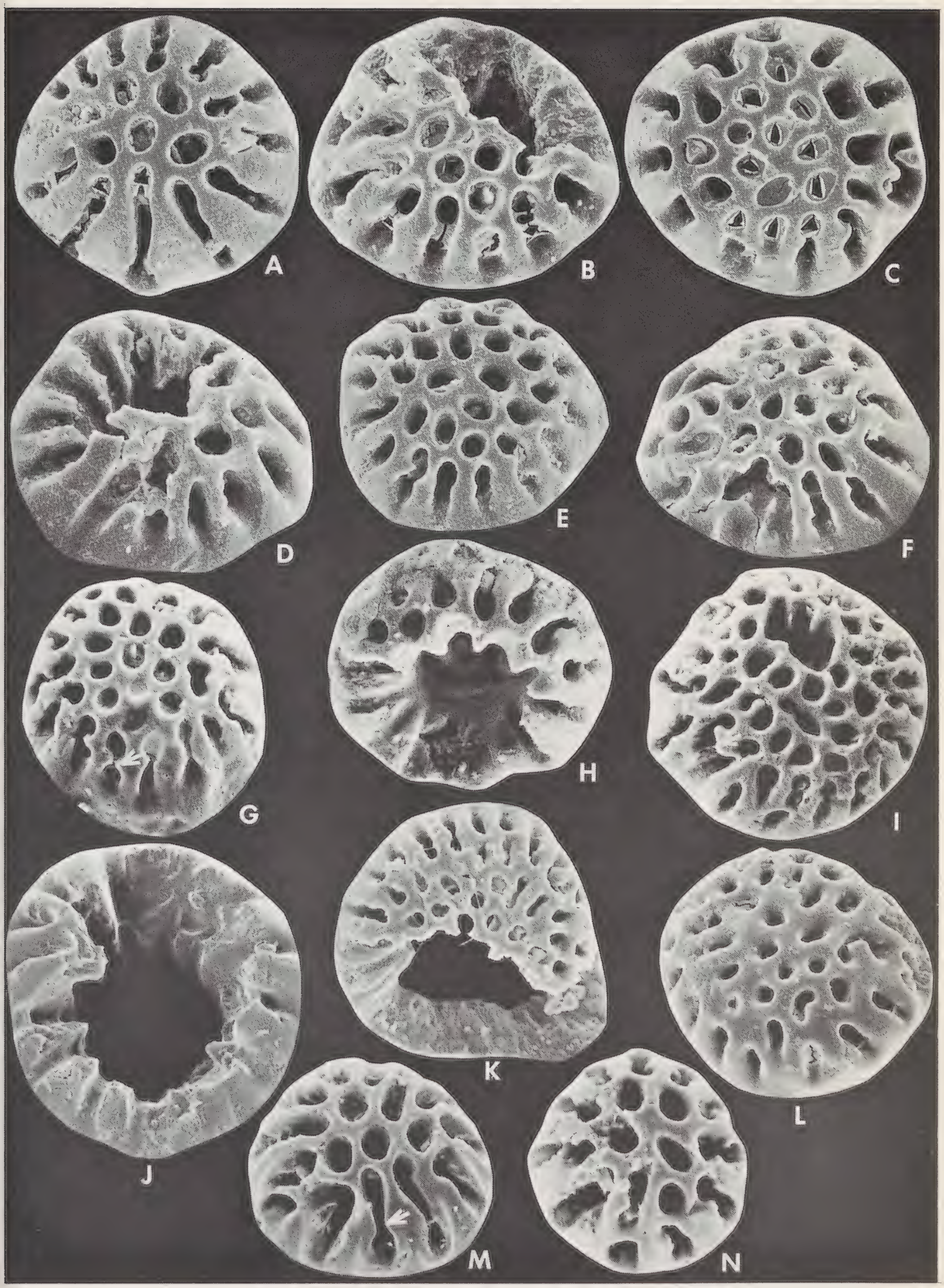

PLATE 3

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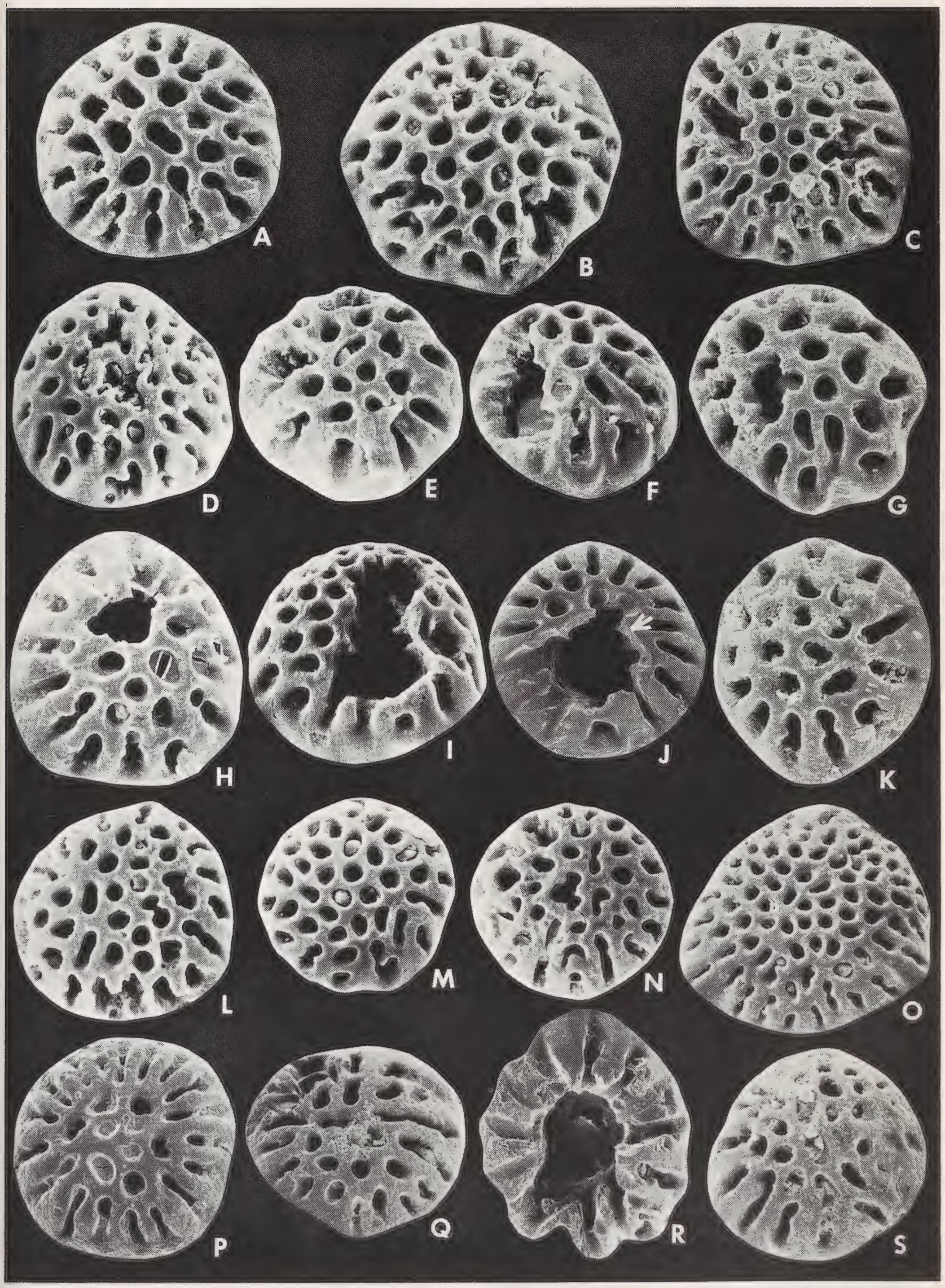
PLATE 4

Figures A-S; Aperture of *Cribrolenticulina akersi* Haman, from Phillips *et al.,* COST #1 well, offshore Texas.

A; Paratype no. 7, sample 2010'-2040'; max. diam. 0.10 mm.
B; Paratype no. 48, sample 2250'-2280'; max. diam. 0.09 mm.
C; Paratype no. 47, sample 2250'-2280'; max diam. 0.13 mm.
D; Paratype no. 38, sample 2250'-2280'; max. diam. 0.09 mm.
E; Paratype no. 29, sample 2070'-2100'; max. diam. 0.09 mm.
F; Paratype no. 30, sample 2070'-2100'; max. diam. 0.09 mm.
G; Paratype no. 14, sample 2010'-2040'; max. diam. 0.07 mm.
H; Paratype no. 21, sample 2010'-2040'; max. diam. 0.08 mm.
I; Paratype no. 37, sample 2250'-2280'; max. diam. 0.09 mm.
J; Paratype no. 6, sample 2250'-2280'; max. diam. 0.14 mm.
Arrow indicates angular edge resultant from mechanical erosion.
K; Paratype no. 20, sample 2010'-2040'; max. diam. 0.07 mm.
L; Paratype no. 49, sample 2250'-2280'; max. diam. 0.09 mm.
M; Paratype no. 51, sample 2250'-2280'; max. diam. 0.09 mm.
N; Paratype no. 44, sample 2250'-2280'; max. diam. 0.09 mm.
O; Holotype no. 50, sample 2250'-2280'; max. diam. 0.13 mm.
P; Paratype no. 10, sample 3690'-3720'; max. diam. 0.13 mm.
Q; Paratype no. 9, sample 3690'-3720'; max. diam. 0.12 mm.
R; Paratype no. 1, sample 2070'-2100' max. diam. 0.11 mm.
S; Paratype no. 31, sample 2070'-2100'; max. diam. 0.10 mm.



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COMMENTS ON THE GENERA *MONTFORTELLA* LOEBLICH AND TAPPAN, 1963, AND *HETEROCIBICIDES* McCULLOCH, 1977 (FORAMINIFERIDA)

DREW HAMAN*
CHEVRON OIL FIELD RESEARCH COMPANY
LA HABRA, CALIFORNIA

The benthic foraminiferal genus *Heterocibicides* was recently established by McCullock (1977) with *Heterocibicides disjuncta* as the type by original designation. Two additional new forms were assigned to this genus by the same author, namely *H.* cf. *disjuncta,* and *H.(?) irregularis.* McCulloch, in her type description of the new genus (p. 449), utilized distinct morphocharacters to differentiate this genus from *Cibicides* de Montfort, 1808. The same morphologic characters were used by Loeblich and Tappan (1963) when they erected the genus *Montfortella,* with *M. bramlettei* as type species. Hence, the genera *Montfortella* and *Heterocibicides* are here considered to be congeneric and *Montfortella* is the valid taxon on the basis of priority.

Loeblich and Tappan (1963), in describing their specimens from the Pleistocene of Santa Barbara and from Recent tide pools at Pacific Grove, California, noted that the genus is "extremely variable in growth form" (p. 213). Variability was also noted by McCulloch (1977, p. 450), with the statement "as of now it seems to be necessary to assume that there is much variation to be expected with reference to presence or absence of imperforate areas, sutural slits and nature of coiling as shown on convex side." McCulloch on the same page further comments on the variability in noting the differences in general morphology between

*Research Associate, Dept. of Geology, Tulane University, New Orleans.

specimens off the Galapagos Islands and specimens obtained off California and Mexico.

Kohl and Haman (in press) also commented on the variable morphology in documenting Mexican Pliocene *Montfortella* from the State of Veracruz. They suggest that this variability results from two growth modes. The first is the result of attachment to various substrates. The forms related to this type of habitat are more "cibicidine" in nature, *i.e.,* plano-convex or variations of this. It is believed that *Heterocibicides disjuncta* and *H.* cf. *disjuncta* would fall into this category. The second growth form they believe to strongly suggest a phytal surface relationship. These forms assume a "pseudoacervuline" or concavo-convex, enrolled mode of growth. *Heterocibicides(?) irregularis* is typical of this type of environment. The test variability is not regarded as reason for specific differentiation by Kohl and Haman, and these authors regard their forms as conspecific with *Montfortella bramlettei* Loeblich and Tappan. It is believed that *Heterocibicides disjuncta* McCulloch, *H.* cf. *disjuncta* McCulloch, and *H.(?) irregularis* McCulloch simply represent variants of *Montfortella bramlettei* Loeblich and Tappan and as such should be regarded as junior synonyms.

Neither Loeblich and Tappan (1963), nor Kohl and Haman (in press) commented on the functional morphology of the radial sutural slits. McCulloch, however, made the observation that the sutural slits permit water circulation to the attached side of the test. No evidence is available to verify or negate this hypothesis.

On the evidence presented by Kohl and Haman the stratigraphic range of *Montfortella* is extended from the Recent and Pleistocene into the Pliocene (Zone N.20. of Blow, 1969). The studies of McCulloch, 1977, provide additional geographical and bathymetric information on the genus. Loeblich and Tappan (1963) obtained specimens from tide pools at Hopkins Marine Station, Pacific Grove, California. McCulloch (1977) recorded the taxon from the Galapagos Islands at a depth of 65 fathoms, off the north side of San Nicolas Island, California at a depth of 49 fathoms, and off San Jose de Caso, Mexico at a depth of 82 fathoms. Consequently, it is evident that the bathymetric range of the form has been considerably extended, as has the Recent areal distribution of the genus in the Pacific.

The author is indebted to A. R. Loeblich and B. Kohl for helpful discussions; to E. Spencer for technical assistance; and to Chevron Oil Field Research Company for publication permission.

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A REVIEW OF THE VOLUTID GENERA *LYRIA* AND *FALSILYRIA* (MOLLUSCA:GASTROPODA) IN THE TERTIARY OF THE WESTERN ATLANTIC

SHIRLEY E. HOERLE
WEST PALM BEACH, FLORIDA
and
EMILY H. VOKES
TULANE UNIVERSITY

CONTENTS

Page
I. ABSTRACT 105
II. INTRODUCTION 106
III. ACKNOWLEDGMENTS 107
IV. SYSTEMATIC DESCRIPTIONS 107
V. LOCALITY DATA 128
VI. LITERATURE CITED 129

ILLUSTRATIONS

PLATE 1 117
PLATE 2 119
PLATE 3 121
PLATE 4 123
PLATE 5 125

I. ABSTRACT

This report covers New World fossil species of two genera of the family Volutidae, *Lyria* and *Falsilyria,* and suggests the relationship between the genera. The previously recorded species of *Lyria* s.s. include one from the Paleocene of Alabama, two from the Oligocene of Mississippi, two from the lower Miocene of Florida, and one from the upper Miocene of the Dominican Republic.To these are added three new species: *Lyria (Lyria) inedita,* from the Clayton Formation of Alabama, *L. (L.) limata,* from the Chipola Formation of Florida, and *L. (L.) incomperta,* from the Gurabo Formation of the Dominican Republic. Two previously described species from the lower Miocene of North Carolina and Florida, respectively, are tentatively referred to the subgenus *Harpeola.* In the subgenus *Enaeta* there are three previously known species, one each from the lower Miocene of Florida, the upper Miocene of the Dominican Republic, and the (?)upper Miocene of Panamá; to these is added a fourth, *L. (Enaeta) olssoni,* n. sp., also from the (?)upper Miocene of Panamá.

Species of the genus *Falsilyria* have been confused with those of *Voluta* and *Lyria* and are intermediate between the two. The

*Research Associate, Paleontological Research Institution, Ithaca, New York; Associate, Department of Earth Sciences, Tulane University.

EDITORIAL COMMITTEE FOR THIS PAPER:

A. MYRA KEEN, Department of Geology, Stanford University (Emeritus), Stanford, California

HAROLD E. VOKES, Department of Earth Sciences, Tulane University, New Orleans, Louisiana

DRUID WILSON, U.S. National Museum, Washington, D.C.

group is confined to the western Atlantic with the known fossil species including two from the Eocene of Florida, one from the Oligocene of Florida and Georgia, two from the lower Miocene of Florida and one from the (?)upper Miocene of Anguilla, B.W.I. One new species, *Falsilyria anoptos,* is described from the Chipola Formation of Florida.

II. INTRODUCTION

Numerous fossil species of the gastropod genus *Lyria* have been recorded from the New World. However, due to the scarcity of individuals of most species, little is known about the relationship of one to another. Fossil *Lyria* were common in the Old World during early Tertiary time and many representatives of the genus are living in the tropical Indo-Pacific region.

LYRIA SENSU STRICTO: *Lyria* is an ultraconservative group without much change in form and color pattern through geologic time. Aldrich (1894, p. 243) named *L. wilcoxiana* from the Paleocene Clayton Formation of Alabama and Gardner (1935, pp. 241, 242, 243) reported three undescribed species of *Lyria* from the Paleocene of Texas. A new species, *L. (L.) inedita,* also from the Paleocene Clayton Formation of Alabama is here added. In the New World between the Paleocene and Oligocene there is a gap in the record, with the exception of a single species reported by Woodring (1964, p. 288, pl. 39, figs. 25, 26) from the Eocene Gatuncillo Formation of the Canal Zone. As his specimen was not a true *Lyria* he erected a new genus, *Ctenilyria,* noting the strong denticulations on the outer lip. Only one other known species, *Voluta coroni* Morlet from the middle and upper Eocene of the Paris Basin, has this feature (Woodring, 1964, p. 288).

In the Oligocene of Mississippi there are two species: *L. nestor* Casey, from the lower Oligocene Red Bluff Formation; and *L. mississippiensis* (Conrad), from the middle and upper Oligocene. In the Miocene beds of Florida there are two species in the Aquitanian Tampa Limestone: *L. silicata* Dall and *L.* sp. cf. *L. mississippiensis* (figured by Dall as *"L. pulchella"*); and one in the Burdigalian Chipola Formation, *L. limata* n. sp. In the upper Miocene Gurabo Formation of the Dominican Republic there are another two species: *L. pulchella* (Sowerby) and *L. incomperta* n. sp. The latter undoubtedly gave rise to one of the two living representatives in the western Atlantic region: *L. vegai* Clench and Turner. The ancestry of the second Recent species, *L. beauii* (Fischer and Bernardi), is less certain. The color pattern is most like that of the lower Miocene *L. limata* but the shell morphology is somewhat different.

ENAETA: Enaeta, a New World subgenus of *Lyria,* apparently arose in the lower Miocene of Florida with *L. (E.) isabellae* (Maury). There is one species from the upper Miocene Gurabo Formation of the Dominican Republic, *L. (E.) perturbatrix* (Maury), and two from the (?)upper Miocene Gatun Formation, Panamá: *L. (E.) ecnomia* (Woodring) and *L. (E.) olssoni* n. sp. This subgenus fares much better in the Recent fauna as there are four described species from the western Atlantic and two from the eastern Pacific.

HARPEOLA: Harpeola, a subgenus of *Lyria,* heretofore has comprised only a few species from the Old World. These differ from *Lyria* sensu stricto in having a channeled suture, causing the whorls to be coronated by the extension of the ribs over the suture. The edge of the outer lip is thickened and usually ornamented with small, blunt denticles. *Lyria heilprini* from the Tampa Limestone of Florida and *L. carolinensis* from the "Silverdale beds" of North Carolina display these diagnostic features and are tentatively assigned to *Harpeola.*

FALSILYRIA: Pilsbry and Olsson (1954, p. 21, 22) erected a new genus *Falsilyria* (type species: *Lyria pycnopleura* Gardner, 1937) stating: "Species of this group have generally been referred to *Lyria,* but its relationship lies closer to the true volutes as shown by its columellar plaits intergrading with smaller lirations on the parietal wall, and by its strong recurved beak and short siphonal fasciole." Another point in common with living specimens of the genus *Voluta* is the color pattern. Under ultraviolet

light the Chipola specimens of *Falsilyria* reveal a typical *Voluta* pattern (see pl. 5, figs. 4c, 4d).

The genus *Voluta* s.s. is endemic to the western Atlantic (Clench and Turner, 1964, p. 139), and the first geologic record of its occurrence is the lower Miocene beds of the Cantaure Formation of Venezuela*. Seemingly, it has never radiated from the Caribbean and all known species, both fossil and Recent, are confined to this area. According to Clench and Turner (1964), the Recent forms occur from the Greater Antilles south to the coast of Brazil and along the mainland as far north as Nicaragua. *Falsilyria* (with a single exception, *F. vaughani* from Anguilla, B.W.I.) is known only from the Gulf of Mexico, with all but one of the known fossil species occurring in the Florida area and a single Recent form in the western Gulf.

Falsilyria and *Voluta* would seem to represent parallel evolution from a common ancestor. The color patterns of the two groups are strikingly similar and so unusual that they frequently look as though they were "drawn" on the shell by an artist with a pen. The most noticable difference between the two groups is the greater width of the shell of the true volutes and a lesser number of columellar plications. In the true volutes the number is about eight to ten, in the genus *Falsilyria* the number is usually nearer 14 in the later species, although it is also about ten in the earlier ones. The protoconch of *Falsilyria* is somewhat smaller than in *Voluta*.

Falsilyria morphologically is intermediate between *Lyria* and *Voluta*, having characteristics of both genera. Presumably diverging from true *Lyria* during the Eocene, *Falsilyria* first occurs in the upper Eocene Inglis Limestone of Florida with two species: *F. eocenica* (Palmer) and *F. citrusensis* (Palmer). In the upper Oligocene of the same area there is *F. mansfieldi* (Dall), of which *F. dalli* (Mansfield) is considered a synonym. *Falsilyria musicina* (Heilprin) occurs in the Aquitanian Tampa Limestone and *F. pycnopleura* and *F. anoptos*, n. sp., are in the Burdigalian Chipola Formation of Florida. There is a single Caribbean species, *F. vaughani* (Cooke) from the (?)upper Miocene of Anguilla, B.W.I. and the only known Recent example is *"Voluta" demarcoi* Olsson, described from the Gulf of Mexico, off the Texas-Mexico border.

*Jung (1965) considered the beds of the Paraguaná Peninsula to be middle Miocene in age; however, Hunter and Bartok (1974), who subsequently named the Cantaure Formation, ascertained the age to be Burdigalian.

III. ACKNOWLEDGMENTS

The writers wish to express appreciation to Druid Wilson and Thomas R. Waller (U.S. National Museum) who made the Museum specimens available for study and provided reference material and to the editorial committee who so patiently read and constructively criticized this paper.

IV. SYSTEMATIC DESCRIPTIONS

Family VOLUTIDAE Rafinesque, 1815
Subfamily LYRIINAE Pilsbry and Olsson, 1954
Genus LYRIA Gray, 1847

Lyria GRAY, 1847, Zool. Soc. London, Proc., (1847), p. 141.
Type species: *Voluta nucleus* Lamarck, 1811, by original designation; Recent, Indo-Pacific.

Otocheilus CONRAD, 1865, Amer. Jour. Conch., v. 1, p. 24.
Type species: *Otocheilus mississippiensis* (Conrad, 1848), here designated [= *Fulgoraria mississippiensis* Conrad, 1848]; Oligocene, Mississippi.

Sannilyria PILSBRY and OLSSON, 1954, Bulls. Amer. Paleontology, v. 35, no. 152, p. 23.
Type species: *Voluta pulchella* Sowerby, 1850, by original designation; Miocene, Dominican Republic.

Subgenus LYRIA s.s.

Diagnosis: Shell globose to fusiform; nucleus slender, consisting of one and one-half to three and one-half smooth whorls; early teleoconch whorls axially costate, subsequent whorls either smooth or ribbed. Suture distinct but not channeled, usually undulated by the axial ribbing. Aperture elliptical, labrum thickened by broad terminal varix, margin sharp, smooth within; columella heavily glazed, two or three prominent oblique plaits anteriorly, few or many weaker lirations on remainder of col-

umellar wall. Siphonal fasciole weakly developed; siphonal notch broad, shallow.

LYRIA (?LYRIA) WILCOXIANA
Aldrich
Plate 3, fig. 5

Lyria wilcoxiana ALDRICH, 1894, Paleontology of the Eocene of Alabama, Geol. Surv., p. 243, pl. 12, fig. 4.

Lyria wilcoxiana Aldrich. HARRIS, 1896, Bulls. Amer. Paleontology, v. 1, no. 4, p. 85, pl. 8, fig. 5.

Lyria Willcoxiana [sic] Aldrich. COSSMANN, 1899, Essais de Paléoconchologie comparée, v. 3, p. 114.

Lyria wilcoxiana Aldrich. BRANN and KENT, 1960, Bulls. Amer. Paleontology, v. 40, no. 184, p. 515.

Lyria wilcoxiana Aldrich. PALMER and BRANN, 1965, Bulls. Amer. Paleontology, v. 48, no. 218, p. 743.

Diagnosis: "Shell rounded fusiform, whorls four, spire blunt, first three whorls smooth, body whorl transversely ribbed, the ribs rather sharp with concave spaces; no spiral sculpture shown; suture distinct, not deeply impressed; body whorl long, terminating in a canal, which is missing in specimen figured; aperture long and narrow, inner lip showing a few plications, but the aperture is filled in so that the lips are almost completely hidden." (Aldrich, 1894)

Dimensions of holotype: height 22.3 mm, diameter 13.5 mm.

Holotype: USNM 111907.

Type locality: USGS 264, Prairie Creek, Wilcox County, Alabama.

Occurrence: Clayton Formation, lower Midway Group, Alabama; Paleocene.

Figured specimen: USNM 111907 (holotype).

Discussion: Apparently the type of *L. wilcoxiana* is unique; this species has not been reported by subsequent workers. The specimen is recrystallized, decorticated, and filled with matrix so that details of the aperture are not preserved; however, as nearly as can be determined it appears to be *Lyria* s.s.

A second species described by Aldrich at the same time (1894, p. 245, pl. 13, fig. 7) as *"Volutalithes" lyroidea* has been referred to the genus *Lyria* by Cossmann (1899, p. 144) and others but examination of the holotype (USNM 111844) does not substantiate this assignment. The type is again a unique specimen, lacking the early whorls. Likewise it is filled with a totally recalcitrant matrix and so the aperture is unknown (see pl. 4, fig. 3). On the basis of the few characters visible it most resembles some form of buccinid.

LYRIA (LYRIA) INEDITA, n. sp.
Plate 4, figs. 1, 2

Diagnosis: Shell fusiform; spire about four-tenths of total height; axially costate throughout. Adult specimens with probably six teleoconch whorls, all material incomplete or immature; nucleus unknown. Suture impressed but not channeled, somewhat undulating. Seven to ten heavy axial costae, sharply rounded, with wide interspaces. Aperture narrow, outer lip thin, smooth within; columella with three strong oblique plications at the anterior end, middle one the strongest, with five to seven nearly horizontal lirations toward the posterior. Weakly developed siphonal fasciole, with a broad, shallow siphonal notch. Shell surface smooth, no spiral ornament.

Dimensions of holotype: height 21.0 mm, diameter 10.6 mm.

Holotype: USNM 25760.

Type locality: McCormic's [McConnico's] plantation, Wilcox County, Alabama.

Paratype: USNM 25759; height 19.0 mm, diameter 10.1 mm; locality, Allenton, Wilcox County, Alabama.

Occurrence: Clayton Formation, lower Midway Group, Alabama; Paleocene.

Figured specimens: Fig. 1, USNM 25760 (holotype). Fig. 2, USNM 25759 (paratype).

Discussion: In the collections of the U.S. National Museum there are several specimens that were catalogued as *"Volutalithes lyroidea* Aldrich." Comparison with the holotype of that species (here figured, pl. 4, fig. 3) reveals that there are marked differences between these specimens and *"V." lyroidea.* The latter is a larger species, with sinuous axial ribs and a strongly recurved siphonal canal. The preservation of the unique holotype is such that an absolute generic identification is impossible but it is certainly not a *Lyria.* The new species, however, is unquestionably referrable to *Lyria* s.s. and as such is the oldest definite member of the subgenus in the New World. As noted above, there are several other species of *"Lyria"* from the Paleocene beds, but only this one has the unmistakable columellar plications, three stronger anterior and several weaker

posterior, with the strong axial ribs that identify the group.

Because of the misidentification as "*V. lyroidea*" this new species has languished in the U.S. National Museum collections for years, thus the name *inedita* (Latin – "not made known, unpublished") seems appropriate.

LYRIA (LYRIA) NESTOR Casey
Plate 1, fig. 1

Lyria costata Sowerby. DALL, 1890, Wagner Free Inst. Sci., Trans., v. 3, pt. 1, p. 85, pl. 6, fig. 2. *(Not* of Sowerby.)

Lyria nestor CASEY, 1903, Acad. Nat. Sci. Phila., Proc., v. 55, pt. 1, p. 282.

Lyria costata (Sowerby). SCHUCHERT *et al.*, 1905, U.S. Natl. Mus., Bull. 53, p. 378 ("Red Bluff, Mississippi"). *(Not* of Sowerby.)

Diagnosis: "It is much more elongate in outline than the Vicksburg species *[L. mississippiensis]*, and is more distinctly sculptured. The longitudinal ribbing is more obtusely rounded and less distinct." (Casey, 1903)

Shell fusiform in outline, spire nearly one-half the total height. Nucleus of three to three and one-half slender smooth whorls, about seven axially costate teleoconch whorls in adult specimens. Costae sinuous, broadly-rounded, with wide interspaces, averaging eleven ribs on final whorl. Suture impressed, undulated by the termination of the axial ribs. Outer lip with heavy varix, margin sharp, non-lirate, thickened within; columella heavily callused, three oblique plaits anteriorly, medial one strongest, posterior weakest, about five widely spaced lirations on remainder of columella area. Teleoconch whorls with closely spaced fine revolving threads, stronger and more widely spaced on basal portion of final whorl. Weakly developed siphonal fasciole; broad, shallow siphonal notch.

Dimensions of lectotype: height 43 mm, diameter 18 mm.

Lectotype: USNM 480042 (selected by MacNeil MS).

Type locality: Red Bluff, Mississippi.

Occurrence: Red Bluff Clay, Mississippi; lower Oligocene.

Figured specimen: USNM 253217; height 33.1 mm, diameter 13.5 mm; locality TU 226.

Discussion: Lyria nestor was not recognized as a distinct species by Dall (1890, p. 85, pl. 6, fig. 2), who confused it with *L. mississippiensis* and *L. costata* (Solander *in* Brander, 1776) of the Barton beds, upper Eocene of southern England. Although the latter bears a superficial resemblance to *L. nestor,* the two species can be readily separated by the higher, more rounded whorls, narrower, less oblique aperture, and less constricted outer lip of the British species. *Lyria mississippiensis* has a proportionately shorter spire, more numerous and sharply-rounded axial costae, and a different arrangement of the plications and lirations on the columella area, thus differentiating the species from *L. nestor.*

The species of *Lyria* that occurs in the Oligocene of Germany, *L. decora* Beyrich, 1853, bears a marked resemblance to *L. nestor;* however, the illustrations given by von Koenen (1890, pl. 37, figs. 9, 10) indicate that the adult shell is more elongate.

Under ultraviolet light *L. nestor* shows the basic spiral lines of color that are typical of the genus *Lyria.*

LYRIA (LYRIA) MISSISSIPPIENSIS (Conrad)
Plate 1, fig. 2

Fulgoraria mississippiensis CONRAD, 1848, Acad. Nat. Sci. Phila., Jour., (2nd Ser.) v. 1, p. 119, pl. 13, fig. 1.

Otocheilus mississippiensis CONRAD, 1865, Amer. Jour. Conch., v. 1, p. 24.

Lyria mississippiensis Conrad?. MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 108, pl. 3, fig. 3.

Lyria sp. cf. *L. mississippiensis* (Conrad). MANSFIELD, 1940, Jour. Paleontology, v. 14, no. 3, p. 208, pl. 27, fig. 41.

Diagnosis: "Elliptical, volutions nine, fluted, the ridges distant, acute, and generally one or two of them large, thick and very remote from each other, on the body whorl; spire conical, acute; aperture auriform; columella with nearly equal plaits, not oblique; labrum thick, with a sharp margin." (Conrad, 1848)

Shell fusiform; spire about one-third total height; axially costate throughout. Adult specimens consisting of six teleoconch whorls plus a small smooth nucleus of three and one-half whorls. Suture impressed but not channeled, undulated by the axial ribs. Fourteen to seventeen sinuous, sharply-rounded axial costae, separated by slightly wider interspaces on final whorl. Aperture lenticular; outer lip thickened by terminal varix, smooth within, margin sharp and reflected; parietal wall heavily callused and lirate, anteriorly three strong plications, abapical two oblique, third a little weaker and horizontal, seven to nine horizontal lirations on remainder of columella. Weakly developed siphonal fasciole; shallow, broad siphonal notch. Close-set, fine, wavy, spiral threads through-

out the extent of the shell, becoming wider-spaced and coarser anteriorly.

Dimensions of lectotype: "height one and one-half inches." (Conrad, 1848)

Lectotype: ANSP 13453 (selected by MacNeil MS).

Occurrence: Byram Marl, Mississippi; Suwannee Limestone, Suwannee County, Florida; middle Oligocene. Chickasawhay Limestone, Alabama; upper Oligocene.

Figured specimen: USNM 253218; height 25.0 mm, diameter 12.0 mm; locality TU 335.

Discussion: As discussed above, *L. mississippiensis* was thought by Dall (1890, p. 85) to be synonymous with *L. costata* (Solander *in* Brander). *Lyria mississippiensis* is distinct, but there was no justification for Conrad (1865) to erect a new genus, *Otocheilus,* to accommodate this species. Conrad listed two species, *O. nereidis* and *O. mississippiensis,* but did not designate which of the two was the genotype. Since the first listed, *O. nereidis,* is "an unfigured and unidentifiable" specimen (Dall, 1890, p. 85) it is assumed he had *L. mississippiensis* in mind. The new genus is unnecessary for, if *L. mississippiensis* is considered the genotype, that species, without question, is a *Lyria.* The slender, smooth nucleus, axially ribbed early whorls, plicated and lirated columella, weakly developed siphonal fasciole, and broad siphonal notch are all features indicative of the genus.

Apparently conditions of preservation were not conducive to retaining any trace of a color pattern: none could be brought out under ultraviolet light.

LYRIA (LYRIA) SILICATA Dall
Plate 4, fig. 7

Lyria silicata DALL, 1915, U.S. Natl. Mus., Bull. 90, p. 59, pl. 10, fig. 3.

Lyria heilprini DALL, 1915, U.S. Natl. Mus., Bull. 90, in part, pl. 10, fig. 13 *only.*

Lyria heilprini Dall. MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 107 (in part).

Diagnosis: "Shell small, light, slender, with 5 or more gently convex whorls, the apex decollate in the type-specimen; suture distinct, not channeled; third whorl (counting backward from the aperture) with about 16 narrow, rather sharp, riblets, with much wider interspaces extending from suture to suture; these riblets on the later whorls become less regularly spaced and obsolete, on the last whorl absent, except for these riblets the surface appears to be smooth; last whorl much the largest, terminating at the outer lip in a thickened, rounded, and expanded varix; aperture narrowly lunate with no sinus or channel at the posterior commissure; inside of the outer lip smooth, without lirae; body with a thin layer of callus; pillar short, thick, with two strong anterior plaits behind which are indications of six or more minor unequal lirae; canal short, wide, deep, the pillar extending a little in advance of the outer lip, twisted, and with a faint siphonal fasciole." (Dall, 1915).

Dimensions of holotype: "Length of (decollate) shell 27.2, of last whorl 22.5, of aperture 16, maximum diameter 14 mm." (Dall, 1915).

Holotype: USNM 165065.

Type locality: Ballast Point, Tampa Bay, Hillsborough County, Florida.

Occurrence: Tampa Limestone, Florida; early lower Miocene.

Figured specimen: USNM 165063; height 34.8 mm, diameter 15.7 mm; locality same as holotype.

Discussion: In the lower Miocene beds of the Tampa Limestone there are three species of *Lyria.* The first named of these was *"Voluta" zebra* Heilprin, 1887, which was renamed *Lyria heilprini* by Dall (1915, p. 58). This species is here referred to *Harpeola* (see below). Unfortunately, the specimen Dall figured as *"L. heilprini"* (1915, pl. 10, fig. 13) is not Heilprin's species but is a tall slender species of *Lyria* s.s. (To further complicate the issue, true *L. heilprini,* i.e., *V. zebra* Heilprin, Dall figured as *"L. pulchella* (Sowerby), on the same plate—pl. 10, fig. 11). At the same time Dall named a second species from the Tampa as *L. silicata.* The type specimen is poorly preserved but there is enough so that when it is compared with the beautiful example figured as *"L. heilprini"* one can see the two represent the same species. The better specimen is here refigured. A third species of *Lyria,* also in the Tampa, is that one figured by Dall in 1890 as *"L. pulchella"* (Sowerby) and here treated as *L.* sp. cf. *mississippiensis.*

The numerous (20-25 on final whorl), low narrow sharp axial ribs with wider interspaces distinguish *L. silicata* from other fossil *Lyria* of the region. The columella is irregularly lirate; the anterior two, occasionally three plications, are the strongest.

LYRIA sp. cf. L. MISSISSIPPIENSIS
Plate 1, fig. 3

Lyria pulchella (Sowerby). DALL, 1890, Wagner Free Inst. Sci., Trans., v. 3, pt. 1, p. 84, pl. 4, fig. 3. (*Not* of Sowerby.)

Lyria pulchella (Sowerby). SCHUCHERT *et al.*, 1905, U.S. Natl. Mus., Bull. 53, p. 378 ("Ballast Point, Tampa, Florida"). (*Not* of Sowerby.)

Diagnosis: Shell fusiform; spire about one-third total height. Unique specimen with five teleoconch whorls and a protoconch of (?) one and one-half bulbous whorls. Suture only slightly impressed, undulating. Fourteen gently rounded axial ribs on each whorl. Aperture incomplete, elongated. Columellar wall bearing but three oblique anterior plications, with very faint lirations posterior to them. Shell surface almost smooth, with a few fine spiral lines on the anterior portion.

Occurrence: Tampa Limestone, Florida; early lower Miocene.

Figured specimen: USNM 112109; height 28.2 mm, diameter 13.1 mm; locality, Ballast Point, Tampa Bay, Hillsborough County, Florida.

Discussion: The shell that Dall (1890, pl. 4, fig. 3) figured as "*Lyria pulchella* (Sowerby)" is not that species. The protoconch is most like *L. pulchella,* and one can see why Dall might have made this identification. However, the shell is much less globose and in overall outline is most like the Oligocene *L. mississippiensis.* The latter has a small protoconch of three and one-half whorls; the Tampa shell has a relatively large protoconch with, as best as can be determined from the silicified specimen, one and one-half whorls.

This is clearly a new species, markedly distinct from the other Tampa form, *L. silicata* Dall, but with no better material than the single specimen presently available it seems best not to describe it at this time.

LYRIA (LYRIA) LIMATA, n. sp.
Plate 1, figs. 4, 5

Diagnosis: Shell slender; fusiform; axially costate. Adult specimens consisting of seven to eight teleoconch whorls plus two and one-half smooth, tapering, nuclear whorls. Teleoconch ornament initiated by weak, slightly sinuous, axial costae. After one-quarter turn axial costae becoming more pronounced, persisting throughout the whorls, twelve to fifteen (usually thirteen) on the final whorl. Suture distinct, but not channeled, undulated by the axial ribbing. Aperture lenticular; outer lip with broad terminal varix, margin sharp and barbed, interior smooth, thickened abapically; parietal wall heavily callused, columella with three strong plaits, the anterior two oblique, the posterior or slightly weaker and more horizontal, seven or eight long lirations, extending into the aperture, on adapical two-thirds of columella area. Spiral sculpture restricted to four to six wavy threads on base. Siphonal fasciole not strongly developed; siphonal notch shallow, broad.

Dimensions of holotype: height 38.8 mm, diameter 16.5 mm.

Holotype: USNM 253219.

Type locality: TU 546, Ten Mile Creek, about 1-1/2 miles west of Chipola River (NW 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida.

Paratype: USNM 253220; height 35.8 mm, diameter 17.6 mm; locality TU 951.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 4, USNM 253219 (holotype). Fig. 5, USNM 253220 (paratype). Other occurrences: TU locality nos. 830, 998.

Discussion: This new species is known to occur only in the lower beds of the Chipola Formation along Ten Mile Creek, near the contact with the underlying Chattahoochee Limestone. It shows a greater affinity to the Oligocene *L. nestor* than to any other fossil species occurring in the southeastern United States; nevertheless, there are distinct differences to be noted. The axial ribbing of *L. limata* is sharper, the whorls are more straight-sided in outline, and the spiral sculpture is confined to the basal area. The outstanding feature that differentiates the Chipola species is the barbs on the sharp margin of the outer lip (pl. 1, fig. 4a). Spiral lines of color extend onto the barbs and on partially corroded shells the spiral lines appear as raised threads.

Lyria limata derives its specific name from the Latin word *limatus,* meaning "elegant," an apt description of this new species. The same adjective can be used to describe the color pattern revealed by ultraviolet light. The Recent Caribbean species, *Lyria beauii* (Fischer and Bernardi, 1857) has a color pattern similar to that seen in *L. limata,* with numerous, strong, spiral color bands and three wider, more diffuse, blotchy bands at the shoulder, the top of the aperture and the base of the body whorl. However, the morphology of the Recent species differs in having the axial ribs more pronounced and angulate at the shoulder.

LYRIA (LYRIA) PULCHELLA (Sowerby)
Plate 2, figs. 3, 4

Voluta pulchella SOWERBY, 1850, Geol. Soc. London, Quart. Jour., v. 6, p. 46, pl. 9, fig. 4.
Voluta soror SOWERBY, 1850, Geol. Soc. London, Quart. Jour., v. 6, p. 46.
Lyria pulchella (Sowerby). GABB, 1873, Amer. Phil. Soc., Trans., (N.S.) v. 15, p. 219.
Voluta pulchella Sowerby. GUPPY, 1876, Geol. Soc. London, Quart. Jour., v. 32, p. 528.
Lyria pulchella Sowerby. DALL, 1890, Wagner Free Inst. Sci., Trans., v. 3, pt. 1, p. 84; in part, *not* pl. 4, fig. 3, = *L.* sp. cf. *L. mississippiensis.*
Lyria pulchella Sowerby. DALL, 1915, U.S. Natl. Mus., Bull. 90, p. 58; in part, *not* pl. 10, fig. 11, = *L. (H.) heilprini* Dall.
Lyria pulchella Sowerby. MAURY, 1917, Bulls. Amer. Paleontology, v. 5, no. 29, p. 73, pl. 11, figs. 10, 10a.
Lyria pulchella (Sowerby). PILSBRY, 1922, Acad. Nat. Sci. Phila., Proc., v. 73, p. 338.
Lyria soror (Sowerby). PILSBRY, 1922, Acad. Nat. Sci. Phila., Proc., v. 73, p. 338, pl. 24, figs. 11, 12.
Lyria pulchella Sowerby. RAMÍREZ, 1949, Publ. Univ. Santo Domingo, (ser. 4a) v. 1, no. 70, p. 24, pl. 3, fig. 8.
Lyria (Sannilyria) pulchella Sowerby. PILSBRY and OLSSON, 1954, Bulls. Amer. Paleontology, v. 35, no. 152, p. 23, pl. 3, fig. 2.
Lyria (Lyria) pulchella (Sowerby). PFLUG, 1961, Acta Humboldtiana, Ser. Geol. Paleont., no. 1, p. 53, pl. 14, figs. 10-15 (figs. 11, 15, lectotype).
Lyria pulchella soror (Sowerby). PFLUG, 1961, Acta Humboldtiana, Ser. Geol. Paleont., no. 1, p. 54, pl. 15, figs. 1, 7 (lectotype).

Diagnosis: "Testa oblongo-ovata, laevis, longitudinaliter costata, anfractibus senis subrotundatis, spira acuminata: costellis plerumque antice subobseletis; labio externo intus laevi, columella plicata, plicis anticis majoribus." (Sowerby, 1850)

Shell globose with short spire; axially costate. Adult specimens consisting of five convex whorls plus one and one-half well-rounded nuclear whorls. Final teleoconch whorl with fourteen to sixteen sharply rounded, slightly sinuous axial costae, costae tending to fade anteriorly. Suture deeply impressed but not channeled. Outer lip ascending, with a broad terminal varix; margin sharp, smooth within. Parietal callus heavy, abapical half free-standing; two, occasionally three, coarse, oblique columellar plaits anteriorly, eight to twelve long lirations ornamenting remainder of columella. Siphonal fasciole weakly developed, with a few fine, wavy, spiral threads; siphonal notch broad and shallow.

Dimension of lectotype: height 37.0 mm, diameter 18.0 mm. (Pflug, 1961, p. 54).

Lectotype: BMNH Nr. G 83 956.

Type locality: Dominican Republic, Rio Amina, west of Potrero (= TU 1219), here designated.

Occurrence: Gurabo Formation, Dominican Republic; upper Miocene.

Figured specimens: Fig. 3, USNM 253223; height 27.4 mm, diameter 17.1 mm; locality TU 1210. Fig. 4, USNM 253224: height 23.5 mm, diameter 14.3 mm; locality Bluff 1, Rio Mao. Other occurrences: TU locality nos. 1211, 1212, 1213, 1214,.1215, 1219, 1227, 1246, 1248.

Discussion: Lyria pulchella is abundant in the Gurabo Formation of the Dominican Republic but it is not known to occur elsewhere. Dall (1890, 1915) employed this name for two different species found in the Tampa Limestone. The first of these is here treated as *L.* sp. cf. *L. mississippiensis,* the second is *L. (H.) heilprini* Dall.

Pilsbry and Olsson (1954, p. 23) erected a new subgenus, *Sannilyria,* for *L. pulchella,* which they stated differed from *Lyria* s.s. in having the parietal wall strongly lirate throughout. However, this trait varies within the genus *Lyria* and does not justify this separation. *Lyria pulchella* exhibits the characteristic features of *Lyria* s.s.: small, smooth nucleus, costate early whorls, plicate and lirate columella, but the outline, with a globose final whorl and short broad spire, distinguishes this species.

Sowerby had no type locality for *Lyria pulchella* other than "Santo Domingo." Inasmuch as the writers and spouses have collected nearly 300 specimens of this species from TU 1219 on the Rio Amina and as this was certainly one of Heneken's localities, it is here designated as the type locality.

The arrangement of broken spiral lines of color pattern appearing on costae only, shown with the aid of ultraviolet light, is illustrated on pl. 2, fig. 4.

LYRIA (LYRIA) INCOMPERTA, n. sp.
Plate 2, figs. 1, 2

Diagnosis: Adult specimens with one and one-half nuclear whorls plus six axially costate whorls. About fourteen low, rounded axial costae, bent forward at the suture and reaching nearly to the base on the final whorl. Suture distinct, slightly undulated by costae. Aperture elliptical; outer lip not ascending, terminal varix broad, smooth within, margin sharp; parietal wall callused, three

strong oblique plaits anteriorly with the posterior one slightly weaker, ten to fifteen long thread-like lirations on remaining portion of columella. A few wavy spiral threads marking the weak siphonal fasciole; siphonal notch broad and shallow.

Dimensions of holotype: height 24.7 mm, diameter 12.7 mm.

Holotype: USNM 253221.

Type locality: TU 1215, bluffs on both sides of Rio Gurabo, from bridge to approximately one km above bridge, Dominican Republic.

Paratype: USNM 253222; height 24.0 mm, diameter 11.7 mm; locality TU 1215.

Occurrence: Gurabo Formation, Dominican Republic; upper Miocene.

Figured specimens: Fig. 1, USNM 253221 (holotype). Fig. 2, USNM 253222 (paratype).

Discussion: Lyria incomperta, as far as is known, is endemic to one locality (TU 1215) in the Gurabo Formation of the Dominican Republic. The fauna at TU 1215 is different from the normal Gurabo Formation and several unusual muricids have been collected from that locality.

Undoubtedly this new species is closely related to *Lyria pulchella;* however, *L. pulchella* is found throughout the Gurabo Formation, except at TU 1215 where it is extremely rare (only four specimens in contrast to 28 examples of *L. incomperta*). In comparison with the frequently occurring *Lyria pulchella, L. incomperta* is a more slender shell with a proportionately higher spire; slightly narrower nucleus; fewer, longer and less sharp axial ribs; thinner parietal glaze; and non-ascending outer lip.

The color pattern, revealed by ultraviolet light, shows not only the usual basic spiral lines typical of the genus, but three bands of square spots on the final whorl (see pl. 2, fig. 2). This color pattern is identical to that exhibited by *Lyria vegai,* only recently named by Clench and Turner (1967, p. 84) from a single specimen taken off the southwestern coast of the Dominican Republic. The Recent species has a higher spire than *L. incomperta* and the axial ribs are almost non-existant.

Considering the limited geographic range of this species in the Gurabo Formation, it is understandable why it has remained "unknown" until now *(incomperta,* Latin adjective for "unknown").

Subgenus HARPEOLA Dall, 1907

Harpella Gray *in* H. and A. Adams, 1858, The genera of Recent Mollusca, v. 2, p. 618 [*non Harpella* Schrank, 1802, Lepidoptera].

Type species: *Voluta costata* Swainson, 1824 [*non Voluta costata* Gmelin, 1791, = *Voluta anna* Lesson, 1835].

Harpeola Dall, 1907, Smithsonian Misc. Coll., v. 48, no. 3, p. 350.

Type species: *Voluta anna* Lesson, 1835, by original designation; Recent, Indo-Pacific.

Diagnosis: "Shell like *Lyria* s.s. but with a channeled suture and shallow posterior sulcus." (Dall, 1907)

Shells are moderate in size; light or solid in weight; protoconch smooth, turbinate or bulbous. Axial ribbing, either narrow or broad, throughout teleoconch. Suture channeled, whorls coronated by extension of axial ribbing. Labrum slightly thickened, with or without feeble denticles on inner margin. Columellar plications, siphonal fasciole and siphonal notch as in *Lyria* s.s.

LYRIA (?HARPEOLA) CAROLINENSIS Kellum

Plate 2, fig. 5

Lyria carolinensis KELLUM, 1926, U.S. Geol. Surv., Prof. Paper 143, p. 40, pl. 11, figs. 4, 5.

Lyria heilprini Dall. MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 107 (in part, *not* of Dall).

Diagnosis: "Shell fusiform, with an elevated spire of about five volutions; nucleus small, smooth; whorls axially sculptured with closely spaced, low costae numbering about 28 on the body whorl; base of body whorl spirally sculptured with a few impressed striae; outer lip thickened on the border, slightly ascending; inner lip irregularly plicated over its entire extent, the two or three basal plicae much the strongest; aperture somewhat more than two-thirds the height of the shell, moderately wide, elliptical, and broadly canaliculate anteriorly." (Kellum, 1926)

Dimensions of holotype: height 31.0 mm, diameter 15.0 mm.

Holotype: USNM 353253.

Type locality: USGS 10655, half a mile southeast of Silverdale, Onslow County, North Carolina, on farm of John Gillette, on left side of Webb Creek (= TU 704).

Occurrence: "Silverdale beds," North Carolina; lower Miocene.

Figured specimen: USNM 253225; height 29.6 mm, diameter 15.0 mm; locality TU 866. Other occurrences: TU 562.

Discussion: The axial costae on the final whorl of *L. carolinensis* have a tendency to become obsolete: thus, with the exception

of the subsutural coronation, the final whorl on some specimens may be entirely smooth. Mansfield (1937, p. 107) considered the Silverdale species to be synonymous with *L. heilprini* Dall and *L. silicata;* however, the latter, which includes the specimen figured by Dall as *L. heilprini,* is a *Lyria* s.s. True *L. heilprini (nom. nov.* for *V. zebra* Heilprin) shares with *L. carolinensis* a slightly channeled suture and paired denticles on the thickened labrum. Both are here tentatively assigned to the subgenus *Harpeola.*

Ultraviolet light reveals an unusual color pattern – "dashed" broken spiral lines. This is unlike that of *L. anna* (type of *Harpeola*), which has a typical *Lyria* pattern of lines and broad bands.

LYRIA (?HARPEOLA) HEILPRINI Dall
Plate 2, fig. 6

Voluta (Lyria) zebra HEILPRIN, 1887, Wagner Free Inst. Sci., Trans., v. 1, p. 110, pl. 15, fig. 46 [*non Voluta zebra* Leach, 1814, Zool. Misc., v. 1, pl. 12, fig. 1].

Lyria zebra Heilprin. DALL, 1890, Wagner Free Inst. Sci., Trans., v. 3, pt. 1, p. 84.

Lyria heilprini DALL, 1915, U.S. Natl. Mus., Bull. 90, p. 58, in part only, *not* pl. 10, fig. 13 (=*L. silicata* Dall) (*nom. nov.* for *V. zebra* Heilprin).

Lyria pulchella Sowerby. DALL, 1915, U.S. Natl. Mus., Bull. 90, pl. 10, fig. 11 *only. (Not* of Sowerby.)

Lyria heilprini Dall. MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 107 (in part).

Lyria heilprini tampaensis MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 108.

Diagnosis: "Shell cylindriform, with an elevated, slightly scalariform spire of about six volutions; whorls costated, the costae (about twenty on the body-whorl) closely-placed, sharply defined, oblique, forming a pseudocoronation on top of the whorls; outer lip greatly thickened on the border, slightly ascending; inner lip irregularly plicated over its entire extent, the three or four basal plicae much the strongest; aperture somewhat more than half the length of shell, narrow, elliptical, contracted basally into a short open canal; surface of shell, barring the costae, smooth over almost of its entire extent, with a few impressed revolving lines on the base of the body-whorl." (Heilprin, 1887)

Dimensions of holotype: height 1-1/4 inches, diameter .6 inch. (Heilprin, 1887)

Holotype: Wagner Free Institute of Science, Philadelphia.

Type locality: Ballast Point, Tampa Bay, Hillsborough County, Florida.

Occurrence: Tampa Limestone, Florida; early lower Miocene.

Figured specimen: USNM 165064 (holotype—*L. heilprini tampaensis* Mansfield); height 28.3 mm; diameter 16.1 mm; locality same as holotype.

Discussion: In his study of the "Tampa Silex beds" Dall (1915, p. 58) renamed the preoccupied *"V." zebra* of Heilprin as *L. heilprini* but figured a specimen markedly different from that shown by Heilprin. The shell figured by Dall at the same time as *"Lyria pulchella"* (1915, pl. 10, fig. 11) is, in fact, the Heilprin species. This confusion resulted in Mansfield (1937, p. 108) naming the *"L. pulchella"* of Dall, 1915, as a new subspecies, *L. heilprini tampaensis.* The specimen figured by Dall as *"L. heilprini"* (*ibid.,* pl. 10, fig. 13) proves to be another species he named at the same time, *L. silicata* (see above). Both specimens are refigured here. Our plate 2, fig. 6, is the shell figured as *"L. pulchella",* which is the type of *L. tampaensis,* and is in truth *L. heilprini,* a new name for *Voluta zebra* Heilprin.

Heilprin, in his original description of this species called attention to the channeled suture, the "pseudocoronation on top of the whorls," and the greatly thickened outer lip. He did not note the small paired denticles on the edge of the outer lip although Mansfield mentioned them in his description of *"L. tampaensis".* All of these characteristics suggest that this species, as well as the closely related *L. carolinensis,* should be referred to *Harpeola.* This subgenus does not exist today in the New World, these two species being the only record of its presence. In the Old World the subgenus occurs in the Eocene of the Paris Basin and the type is found in the Recent of the Indo-Pacific area.

Subgenus ENAETA H. and A. Adams, 1853

Enaeta H. and A. ADAMS, 1853, The genera of Recent Mollusca, v. 1, p. 167.

Type species: *Voluta harpa* Barnes, 1824, by subsequent designation of Cossmann, 1899; Recent, eastern Pacific. [*Voluta harpa* Barnes, 1824, *non* Mawe, 1823, = *Voluta barnesii* Gray, 1825 (as *barnsii*)].

Diagnosis: Shell fusiform or ovate-fusiform; nucleus narrow; early teleoconch whorls costate, subsequent whorls may or may not be costate. Columella with two to four oblique plications anteriorly, few or many lirations on remainder of

columella. Suture adpressed. Siphonal fasciole moderately developed; siphonal notch narrow, deep. A tooth-like projection about midpoint on inside of outer lip, inner edge of outer lip either crenulated or smooth.

Discussion: The type species of *Enaeta* has usually been cited as "*Voluta barnesii* Gray;" however, that species was not among the original list of species given by Adams and Adams (1853, p. 167). The oldest valid designation of *Voluta harpa* Barnes as type is that of Cossmann (1899, p. 105).

LYRIA (ENAETA) ISABELLAE (Maury)

Plate 3, figs. 1, 2

Caricella isabellae MAURY, 1910, Bulls. Amer. Paleontology, v. 4, no. 21, p. 17, pl. 4, fig. 7.

Strigatella americana DALL, 1915, U.S. Natl. Mus., Bull. 90, p. 61, pl. 9, fig. 2.

Strigatella isabellae (Maury). GARDNER, 1937, U.S. Geol. Surv., Prof. Paper 142-F, p. 419.

Enaeta americana (Dall). PILSBRY and OLSSON, 1954, Bulls. Amer. Paleontology, v. 35, no. 152, p. 24, pl. 3, fig. 3 (holotype).

[Enaeta] isabellae Maury. WOODRING, 1964, U.S. Geol. Surv., Prof. Paper 306-C, p. 289 (with "*Strigatella*" *americana* Dall in synonymy).

Mitreola americana (Dall). CERNOHORSKY, 1970, Aukland Inst. Mus., Bull., no. 8, p. 88, pl. 12, fig. 5 (after Pilsbry and Olsson, 1954, pl. 3, fig. 3).

Lyria (Enaeta) isabellae (Maury). CATE, 1972, Tulane Stud. Geol. Paleont., v. 10, no. 1, p. 47-50, pl. 1, fig. 1-3.

Diagnosis: "Shell of moderate size, thick and strong, whorls 6, exclusive of the eroded nucleus; suture distinct. Sculpture consisting only of numerous longitudinal striations. Columella with 4 plaits; canal short; reflexed." (Maury, 1910)

Dimensions of holotype: height 27.4 mm, diameter 14.0 mm.

Holotype: PRI 3446.

Type locality: USGS 2212 (= TU 546), here designated.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 1, USNM 114343 (holotype — *S. americana* Dall); height 28.2 mm, diameter 14.0 mm; locality USGS 2212 (= TU 546). Fig. 2, USNM 646935; height 24.2 mm, diameter 13.0 mm; locality TU 951. Other occurrences: TU locality nos. 457, 458, 547, 830, 951, 998.

Discussion: As was discussed in the Introduction of this paper, fossil representatives of the subgenus *Enaeta* are limited in numbers; only four species are known, the Chipola form being the oldest. This species cannot be considered rare, particularly in the lower beds along Ten Mile Creek, as there are over 90 specimens in our collections, only three of which came from river localities — one each from TU 457, 458, and 547. *Lyria isabellae* has axial ornament on only the first three post-nuclear whorls, but the growth lines are so strong the shell has the appearance of being delicately axially ribbed. The early teleoconch whorls are finely spirally striated, these spiral lines fading on the final whorl in front of the suture. All the specimens examined showed only the four coarse plications on the columella, no auxiliary lirations as noted on other species of *Enaeta.* The outer lip is thickened by a terminal varix and bears a blunt tooth about midway. The outline of this species is similar to that of the Recent eastern Pacific *Enaeta barnesii,* and with the aid of ultraviolet light the color pattern of the fossil species may be seen to resemble that of the Recent species. For further discussion of *Lyria (Enaeta) isabellae,* the reader is referred to Cate (1972, p. 47-50).

Maury's locality for "*Caricella*" *isabellae* was only "Chipola Marls, Bailey's Ferry, Fla." As noted in previous publications in this series the Chipola Formation does not occur at Bailey's Ferry. The type locality of Dall's "*Strigatella*" *americana* is USGS 2212, one mile west of Bailey's Ferry on Ten Mile Creek [Cate's reference to TU 457 is an error] and, as the majority of specimens occur in that area, USGS 2212 (= TU 546) is here designated as the type locality for *Lyria (Enaeta) isabellae.*

LYRIA (ENAETA) ECNOMIA (Woodring)

Enaeta ecnomia WOODRING, 1964, U.S. Geol. Surv., Prof. Paper 306-C, p. 289, pl. 46, figs. 2, 3.

Diagnosis: "Of medium size, columbelloid, inflated, spire rapidly tapering. Body whorl bearing a faint sutural collar. Protoconch worn and partly missing. First three post-protoconch whorls bearing low, wide axial ribs. Ribs more subdued and retractive on remaining spire whorls: 18 ribs on body whorl. Spiral sculpture limited to weak threads, aside from a stronger thread bordering siphonal

fasciole. Outer lip thickened, ascending, interior bearing a heavy denticle about two-thirds of distance from anterior end to posterior end of lip. Siphonal fasciole moderately inflated. Columella bearing four folds, not including two minor folds on parietal wall." (Woodring, 1964)

Dimensions of holotype: height 20.2 mm, diameter 11.5 mm.

Holotype: USNM 643693.

Type locality: USGS 16909, Transisthmian Highway, latitude 9° 21' N, plus 1,525 meters, longitude 70° 50' W, plus 300 meters, Panamá.

Occurrence: Lower part of Gatun Formation, Panamá; (?)upper Miocene.

Discussion: Woodring (1964, p. 289) noted that *Enaeta ecnomia* is closely related to the Recent eastern Pacific *Enaeta barnesii,* type of the genus. Minor features, such as a smaller size, faint sutural collar, stronger spiral threads, weaker and less numerous axial ribs, and stronger columellar plications, distinguish the Gatun species from the Recent species. The holotype of *E. ecnomia* is the sole representative of the species.

LYRIA (ENAETA) OLSSONI, n. sp.

Plate 3, fig. 4

Diagnosis: Shell solid, fusiform; nucleus unknown, six teleoconch whorls remaining. Early whorls faintly axially ribbed, only growth lines evident on final whorl; suture closely adpressed. Spire short, a little less than one-third the height of entire shell. Outer lip broken; columella slightly sinuous with weak callosity, lirate throughout, three strong oblique plaits anteriorly, changing to lirae, more horizontal in direction, posteriorly. Siphonal fasciole moderately developed; siphonal notch narrow and deep.

Dimensions of holotype: height 32.0 mm, diameter 16.3 mm.

Holotype: USNM 253227.

Type locality: TU 757, Panamá Highway 3, at junction of road to "Refinera Panamá, S.A.," just east of Cativa, Colón, Panamá.

Occurrence: Gatun Formation, Panamá; (?)upper Miocene.

Figured specimen: USNM 253227 (holotype).

Discussion: There are two species of *Enaeta* in the Gatun Formation of Panamá. Although each is represented by a single specimen they are so completely distinct there is no possibility that they are the same species. *Lyria (Enaeta) ecnomia* Woodring is much like the Recent Pacific *L. barnesii,* whereas *L. olssoni* is more nearly akin to the Chipola *L. isabellae.* The spire of *L. isabellae* is more elongate and the columella of *L. (E.) olssoni* is lirate throughout its length with three strong oblique plaits anteriorly, but the Chipola species has no lirations on the posterior portion of the columella with four strong plicae anteriorly.

Although the nucleus is lost and the lip is badly damaged on this unique specimen, there can be no question as to its taxonomic placement. The adpressed suture, moderately developed siphonal fasciole and narrow, deep siphonal notch are indicative of the subgenus *Enaeta.* The color pattern (pl. 3,

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PLATE 1

Figures — Page

1. *Lyria nestor* Casey (x 2) 109
USNM 253217; height 33.1 mm, diameter 13.5 mm.
Locality: TU 226, Wayne Co., Mississippi. Red Bluff Clay, lower Oligocene.

2. *Lyria mississippiensis* (Conrad) (x 2) 109
USNM 253218; height 25.0 mm, diameter 12.0 mm.
Locality: TU 335, Vicksburg, Mississippi. Byram Marl, middle Oligocene.

3. *Lyria* sp. cf. *L. mississippiensis* (x 1-1/2) 110
USNM 112109; height 28.2 mm, diameter 13.1 mm.
Locality: Ballast Point, Tampa Bay, Florida. Tampa Limestone, early lower Miocene.

4, 5. *Lyria limata* , n. sp. (x 1-1/2) 111
4. USNM 253219 (holotype): height 38.8 mm, diameter 16.5 mm.
Locality: TU 546, Ten Mile Creek. Chipola Fm., late lower Miocene.
5. USNM 253220 (paratype); height 35.8 mm, diameter 17.6 mm.
Locality: TU 951, Ten Mile Creek. Chipola Fm., late lower Miocene.

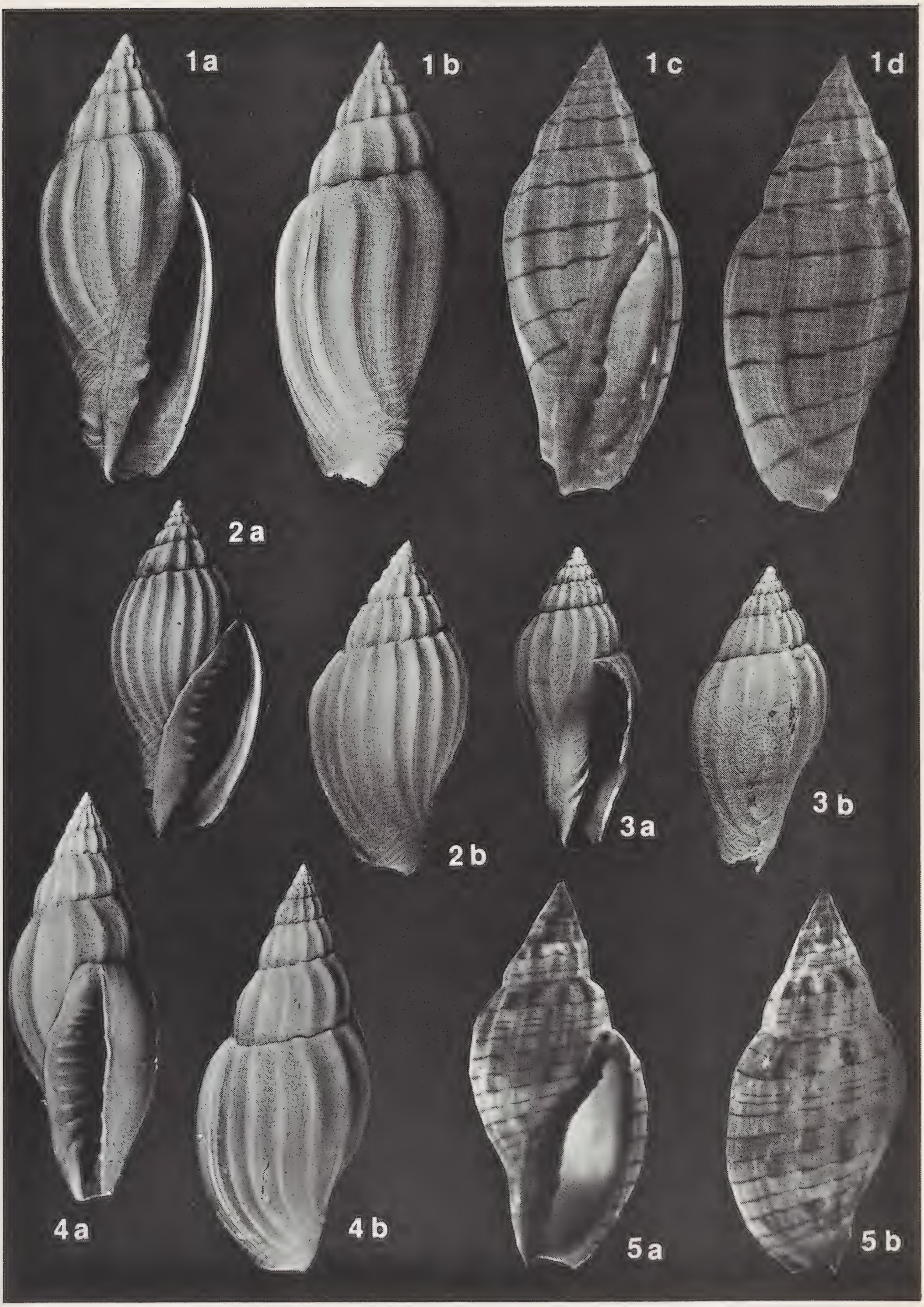

PLATE 1

fig. 4c) further substantiates its assignment.

This new species is named in honor of the late Dr. Axel A. Olsson of Coral Gables, Florida, as it was in his Panamá collection that this unusual specimen was found.

LYRIA (ENAETA) PERTURBATRIX (Maury)

Plate 3, fig. 3

Mitra (Strigatella?) perturbatrix MAURY, 1917, Bulls. Amer. Paleontology, v. 5, no. 29, p. 76, pl. 14, figs. 1, 2.

[Enaeta] perturbatrix Maury. WOODRING, 1964, U.S. Geol. Surv., Prof. Paper 306-C, p. 289.

Diagnosis: "Shell slender, somewhat Columbelliform, spire a trifle shorter than the aperture; suture distinct; whorls eight, the first two smooth, nuclear; post-nuclear whorls slightly convex, ornamented with weak, equidistant longitudinal plications, about twenty on each of the last two whorls; the plications are strongest over the convex portion of the volutions and fade out near the sutures; aperture narrowly elliptical, inner lip with a callus; columella with three sharp anterior and two weaker posterior plications; outer lip thickened with a stout, marginated external band, marked by an internal posterior Strombinoid notch and showing traces of obsolescent crenulations within, not lirate." (Maury, 1917)

Dimensions of lectotype: height 19.5 mm, diameter 8.5 mm.

Lectotype: PRI 28710 (here designated).

Type locality: Zone D, Rio Gurabo at Los Quemados, Dominican Republic (= TU 1215).

Occurrence: Gurabo Formation, Dominican Republic; upper Miocene.

Figured specimen: USNM 253226; height 20.5 mm, diameter 9.0 mm; locality TU 1215.

Discussion: Only three examples of this species are known, two "co-types" and one from the Tulane University collection, here figured. In the type lot of Maury's species there are two specimens now catalogued at the Paleontological Research Institution as nos. 28709 (pl. 14, fig. 1) and 28710 (pl. 14, fig. 2). Neither specimen has the measurements cited by Maury (both are 19.5 mm in height); thus, that figured in the apertural view (PRI 28710) is here selected as the lectotype. The outer lip of *L. perturbatrix* is thickened, the inner edge having feeble short denticles on the anterior two-thirds with one strong blunt tooth adapical to the denticles, and a rounded callosity in front of the posterior commissure (see pl. 3, fig. 3c). The blunt tooth about midway on the labrum is a characteristic of the subgenus *Enaeta,* but the faint crenulations and rounded callosity do not appear on any of the known fossil species. *L. (Enaeta) cylleniformis* (Sowerby), a Recent Caribbean species, shows the same features but is a heavier, stouter shell, with more prominent axial ornament. Two other Recent western Atlantic species show strong similarities to *L. perturbatrix*: *L. (Enaeta)*

PLATE 2

Figures — Page

1, 2. *Lyria incomperta*, n. sp. (x 2) 112
1. USNM 253221 (holotype); height 24.7 mm, diameter 12.7 mm.
Locality: TU 1215, Rio Gurabo. Gurabo Fm., upper Miocene.
2. USNM 253222 (paratype); height 24.0 mm, diameter 11.7 mm.
Locality: TU 1215, Rio Gurabo. Gurabo Fm., upper Miocene.

3, 4. *Lyria pulchella* (Sowerby) (x 2) 112
3. USNM 253223; height 27.4 mm, diameter 17.1 mm.
Locality: TU 1210, Rio Gurabo. Gurabo Fm., upper Miocene.
4. USNM 253224; height 23.5 mm, diameter 14.3 mm.
Locality: Rio Mao Bluff 1. Gurabo Fm., upper Miocene.

5. *Lyria (?Harpeola) carolinensis* Kellum (x 2) 113
USNM 253225; height 29.6 mm, diameter 15.0 mm.
Locality: TU 866, Silverdale, North Carolina. "Silverdale beds," early lower Miocene.

6. *Lyria (? Harpeola) heilprini* Dall (X 2) 114
USNM 165064; height 28.3 mm, diameter 16.1 mm.
Locality: Ballast Point, Tampa Bay, Florida. Tampa Limestone, early lower Miocene.

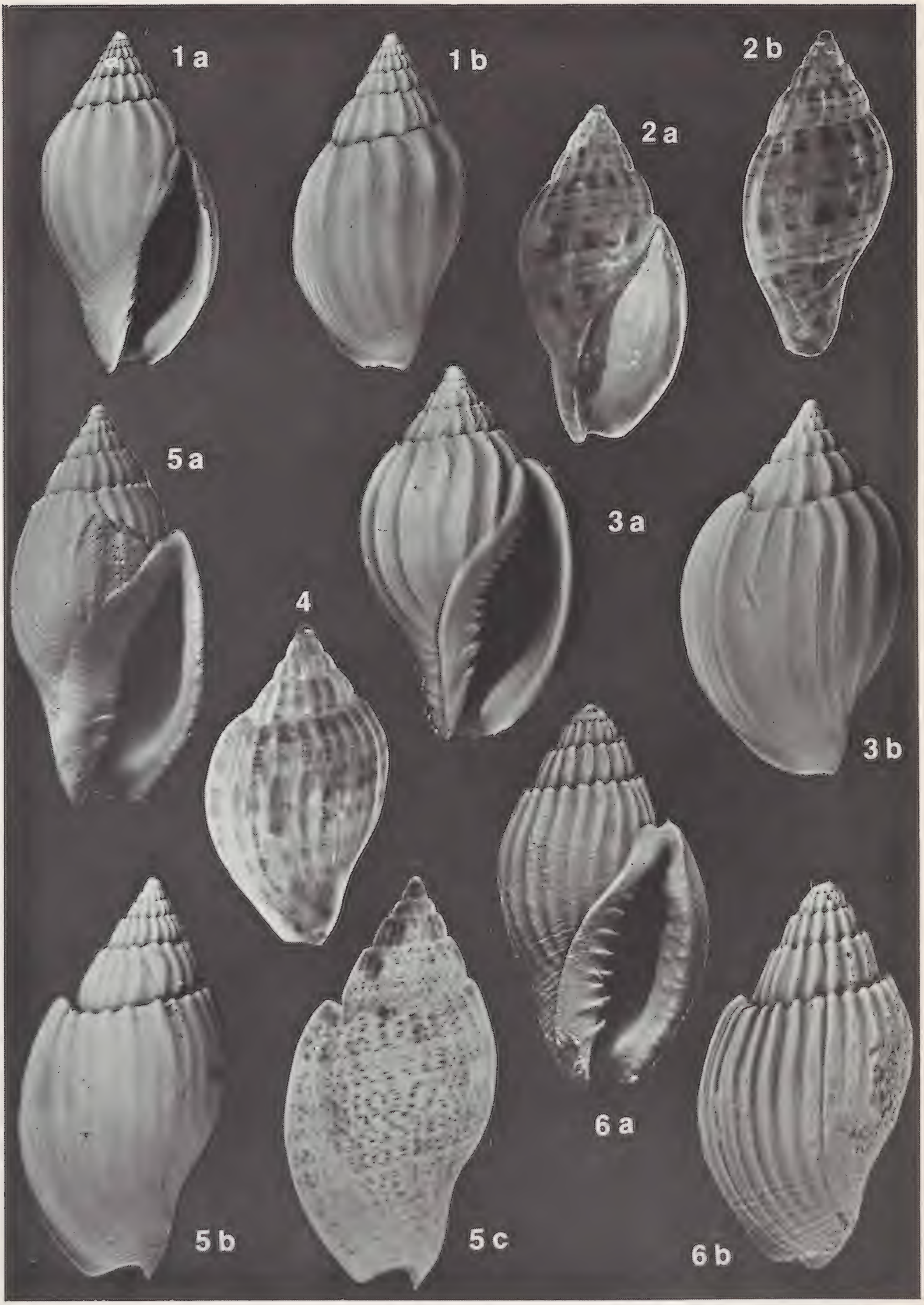

PLATE 2

reevei (Dall, 1907) [a new name for *Voluta guttata* Reeve, 1849, *non* Dillwyn, 1817], which has a shorter spire; and *L. (Enaeta) guildingi* (Sowerby, 1844), which has a higher spire. Neither has the posterior callosity as well developed as in *L. (Enaeta) perturbatrix,* which is almost certainly ancestral to both.

The color pattern of *Enaeta* is usually strong and distinctive; however, treatment with sodium hypochlorite failed to induce a color pattern on this specimen.

Subfamily VOLUTINAE Rafinesque, 1815
Genus FALSILYRIA Pilsbry and Olsson, 1954

Falsilyria PILSBRY and OLSSON, 1954, Bulls. Amer. Paleontology, v. 35, no. 152, p. 21.

Type species: *Lyria pycnopleura* Gardner, 1937, by original designation.

Diagnosis: "Similar to *Voluta* Linné but with a narrower shell and higher spire; nucleus relatively small, consisting of but one [to two plus] rather loosely coiled whorl; sculpture formed by strong, smooth, nearly straight axial ribs, generally somewhat noded or coronated at the suture and with faint spirals showing around the base and on the canal; aperture semi-elliptical, the outer lip thickened by the last rib, smooth within; plaits on the columella and parietal wall are similar to those of *Voluta;* of these the four or five lower ones form large, strong, sharp folds which spiral deeply into the interior while above them the plaits on the parietal wall are small and weak; end of pillar appressed and turned sharply backwards to form a recurved beak forming a deep, siphonal notch; siphonal fasciole short but strong." (Pilsbry and Olsson, 1954)

FALSILYRIA EOCENIA (Palmer)

Lyria pycnopleura eocenia PALMER, 1953, Florida Geol. Surv., Bull. 35, p. 38, pl. 5, figs. 1, 14.

Diagnosis: "Shell medium in size, solid, spire elevated; postnuclear whorls five; nuclear whorls smooth, of about 2 or 2-1/2 whorls; whorls with eight or nine large coarse longitudinal lirae, those over the body whorl somewhat irregular in size and position; the lirae crossed by fine spiral striations, most conspicuous on the body whorl; below the suture there is a concave appressed area which causes the lirae to be nodose between it and the suture and the lirae slightly nodose just below it; anterior notch recurved, short in length but deep with coarse spiral lines above it; columellar callus thick; plications medium in size." (Palmer, 1953)

Dimensions of holotype: height 21+ mm, diameter 11.0 mm.

Holotype: Florida Geol. Surv. I-7630.

Type locality: Road metal pit 2.9 miles south of the north limits of town of Gulf Hammock (SW 1/4, Sec. 34, T14S, R16E), Levy County, Florida.

Occurrence: Inglis Limestone, Florida; early upper Eocene.

Discussion: Palmer (1953, p. 38) reported two species here referred to *Falsilyria* from the Inglis Formation, upper Eocene, in central Florida. She considered one of these,

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PLATE 3

Figures — Page

1, 2. *Lyria (Enaeta) isabellae* (Maury) (x 2) 115
1. Holotype – *Strigatella americana* Dall.
USNM 114343; height 28.2 mm, diameter 14.0 mm.
Locality: USGS 2212 (= TU 546), Ten Mile Creek. Chipola Fm., late lower Miocene.
2. USNM 646935; height 24.2 mm, diameter 13.0 mm.
Locality: TU 951, Ten Mile Creek. Chipola Fm., late lower Miocene.

3. *Lyria (Enaeta) perturbatrix* (Maury) 118
USNM 253226; height 20.5 mm, diameter 9.0 mm.
Locality: TU 1215, Rio Gurabo. Gurabo Fm., upper Miocene.
(3a, 3b x 2), (3c x 3)

4. *Lyria (Enaeta) olssoni*, n. sp. (x 2) 116
USNM 253227 (holotype); height 32.0 mm, diameter 16.3 mm.
Locality: TU 757, Cativa, Panamá. Gatun Fm., (?) upper Miocene.

5. *Lyria(?) wilcoxiana* Aldrich (x 2) 108
USNM 111907 (holotype); height 22.3 mm, diameter 13.5 mm.
Locality: Prairie Creek, Wilcox Co., Alabama. Clayton Fm., Paleocene.

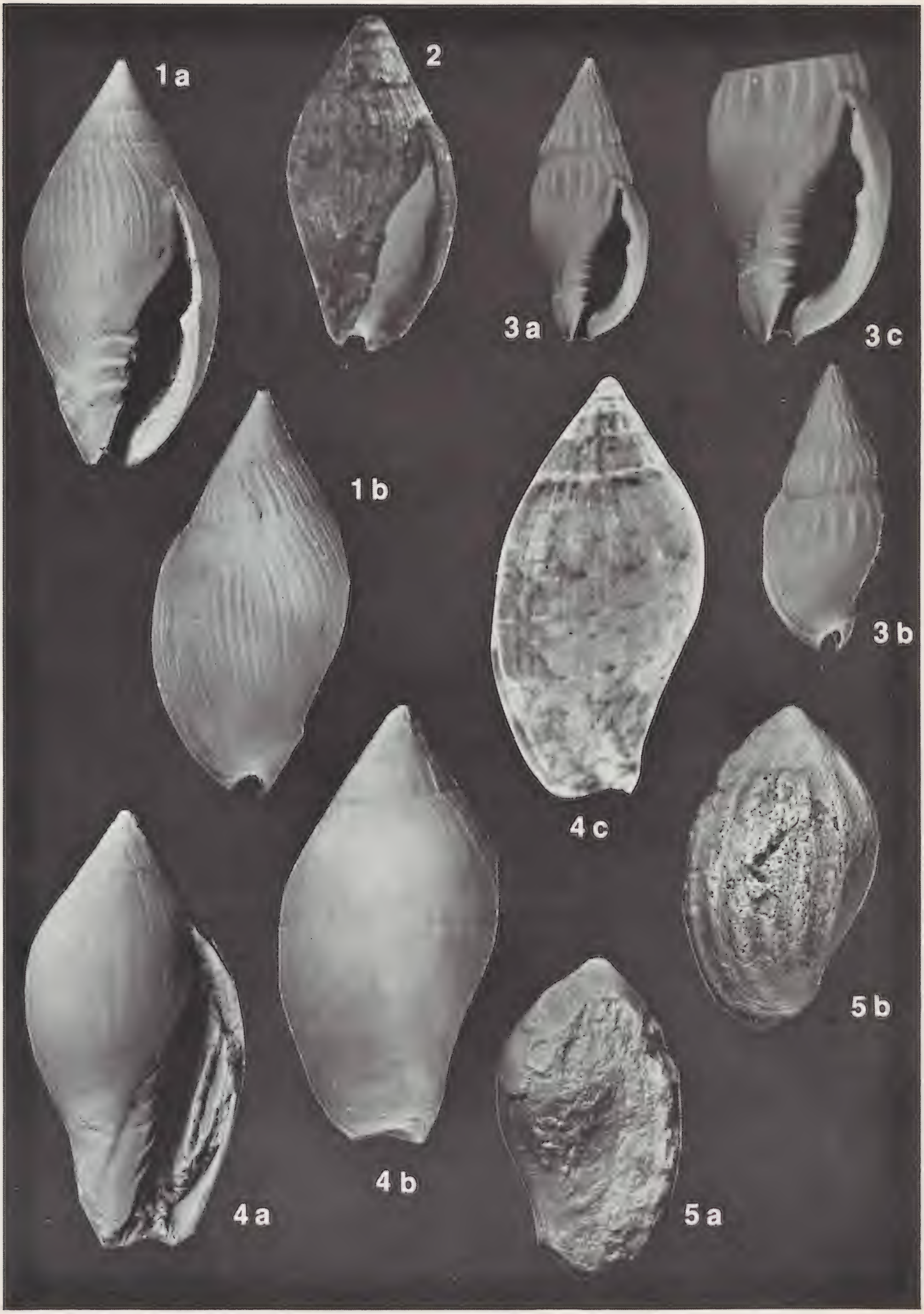

PLATE 3

Lyria pycnopleura eocenia (ibid. pl. 5, figs, 1, 14), to be a subspecies of Gardner's Chipola form *L. pycnopleura* because of the similarity in shape, longitudinal costae and groove in front of the suture. In the opinion of the writers, the figures depict a shell more nearly corresponding to *L. musicina* Heilprin from the Tampa Limestone. Both *L. pycnopleura* and *L. musicina* have a groove in front of the suture that causes the posterior extremity of the costae to appear nodose, but only *L. musicina* has numerous revolving threads over the entire shell. Both *F. eocenia* and *F. musicina* retain the narrow nucleus of *Lyria.* This latter feature demonstrates that this *Falsilyria* is an early stage of evolvement from the genus *Lyria. Falsilyria pycnopleura* has a broader nucleus, and the anterior portion of the columella is beginning to broaden, indicating its closer affinity to *Voluta.*

FALSILYRIA CITRUSENSIS (Palmer)

Lyria citrusensis PALMER, 1953, Florida Geol. Surv., Bull. 35, p. 38, pl. 8, fig. 7.

Diagnosis: "Shell medium in size, robust; spire short; whorls about four; nuclear whorls worn; whorls with strong longitudinal ribs, about nine or ten ribs on the body whorl, the last enlarged fold forming a strong varix on the margin of the labrum; concave groove below the suture developing a shoulder to the ribs; about 10 plications on columella, the anterior ones are larger and more regular." (Palmer, 1953)

Dimensions of holotype: height 22.0 mm, diameter 13+ mm.

Holotype: Fla. Geol. Surv. I-7629 (plastotype).

Type locality: Pit of Dunnellon Phosphate Mining Co. (SW 1/4 of SE 1/4, Sec. 10, T18S, R19E), Citrus County, Florida.

Occurrence: Inglis Limestone, Florida; early upper Eocene.

Discussion: Palmer's second species from the Inglis Limestone, *F. citrusensis,* is "represented by the holotype only which is a plastotype;" consequently, some of the various morphological characteristics are indistinct. Palmer stated this species also has the "concave groove below the suture developing a shoulder to the ribs" but differentiates *L. citrusensis* from *L. eocenia* by its "short spire, the plumper shape and lack of spiral threads." Perhaps the two Eocene species should be synonymized, but due to the lack of specimens, the writers hesitate to do so at this time.

PLATE 4

Figures Page

1, 2. *Lyria (Lyria) inedita,* n. sp. (X 2) 108
1. USNM 25760 (holotype); height 21.0 mm, diameter 10.6 mm.
Locality: Wilcox Co., Alabama. Clayton Fm., Paleocene.
2. USNM 25759 (paratype); height 19.0 mm, diameter 10.1 mm.
Locality: Allenton, Wilcox Co., Alabama. Clayton Fm., Paleocene.
3. *"Volutalithes" lyroidea* Aldrich (X 1-1/2) 108
USNM 111844 (holotype); height 30.2 mm, diameter 14.8 mm.
Locality: Prairie Creek, Wilcox Co., Alabama. Clayton Fm., Paleocene.
4, 5. *Falsilyria mansfieldi* (Dall) (x 1-1/2) 124
4. USNM 166724 (holotype-*mansfieldi* Dall); height 47.0 mm, diameter 21.3 mm.
Locality: Flint River, Decatur Co., Georgia. Flint River Fm. upper Oligocene.
5. USNM 495942 (holotype-*dalli* Mansfield); height 37.8 mm, diameter 18.7 mm.
Locality: Blackwater Creek, Hillsborough Co., Florida. Suwannee Limestone, upper Oligocene.
6. *Falsilyria musicina* (Heilprin) (x 1-1/2) 124
USNM 112106; height 42.3 mm, diameter 21.8 mm.
Locality: Ballast Point, Tampa Bay, Florida. Tampa Limestone, early lower Miocene.
7. *Lyria (Lyria) silicata* Dall (X 1-1/2) 110
USNM 165063; height 34.8 mm, diameter 15.7 mm.
Locality: Ballast Point, Tampa Bay, Florida. Tampa Limestone, early lower Miocene.

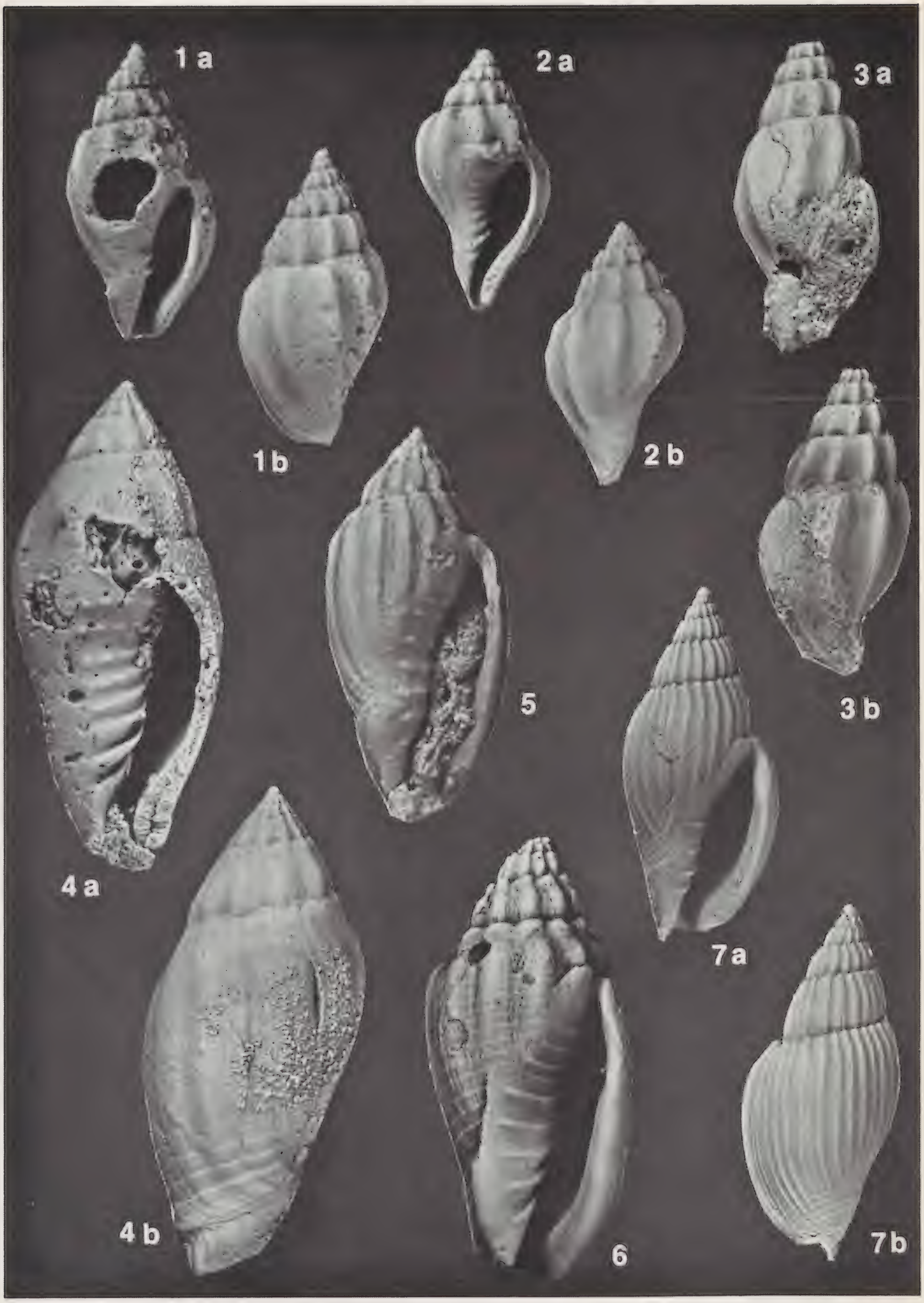

PLATE 4

FALSILYRIA MANSFIELDI (Dall)

Plate 4, figs. 4, 5

Lyria mansfieldi DALL, 1916, U.S. Natl. Mus., Proc., v. 51, no. 2162, p. 504, pl. 86, fig. 3.

Lyria musicina dalli MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 106, pl. 3, fig. 2.

Diagnosis: "Shell fusiform, solid, with about seven whorls, excluding the (lost) nucleus; suture distinct but not impressed; whorls rapidly enlarging, moderately convex, with an acute apex; axial sculpture of about (on the penultimate whorl) nine low and ill-defined ribs, none distinct on the earlier whorls and on the last whorl becoming obsolete anteriorly; the lines of growth are also rather marked; spiral sculpture near the canal of four or five flattish threads with wider interspaces; the canal is bent to the right and has a distinct siphonal fasciole; outer lip defective; inner lip with eight or more columellar plaits more prominent anteriorly, with a rather heavy callus on the body near the junction of the outer lip." (Dall, 1916)

Dimensions of holotype: height 47.0 mm, diameter 21.3 mm.

Holotype: USNM 166724.

Type locality: USGS Station 7096, at Red Bluff, on west bank of Flint River, 7 miles above Bainbridge, Decatur County, Georgia.

Occurrence: Flint River Formation, Georgia; Suwannee Limestone, Florida; upper Oligocene.

Figured specimens: Fig. 4, USNM 166724 (holotype). Fig. 5, USNM 495942 (holotype-*Lyria musicina dalli* Mansfield); height 37.8 mm, diameter 18.7 mm; locality, Blackwater Creek, at S.A.L. Railway crossing, Hillsborough County, Florida.

Discussion: The aperture of the holotype of *"Lyria" mansfieldi* is broken, but the columellar plications are still present and it is obvious from them that the species should be referred to the genus *Falsilyria.* They are identical to those of the younger *F. pycnopleura* (compare with pl. 5, fig. 2). The axial ribs show the subsutural groove only faintly delineated. This may be an evolutionary trend as later forms show a stronger groove, culminating in the (?)upper Miocene *F. vaughani* (Cooke).

Mansfield (1937, p. 106) named *"Lyria dalli"* as a subspecies of *"Lyria" musicina* (Heilprin). He did not compare his specimen with Dall's *"L." mansfieldi,* although the two forms are of the same age. He should have, for it seems obvious when one does that the two are synonymous. The holotype of *F. mansfieldi* is larger and the axial ribs of the body whorl are not as strongly developed as those of the body whorl of *"L." dalli;* however, examination of a specimen of *F. pycnopleura* (pl. 5, fig. 1) indicates that this is the normal state for a fully mature individual.

FALSILYRIA MUSICINA (Heilprin)

Plate 4, fig. 6

Voluta musicina HEILPRIN, 1887, Wagner Free Inst. Sci., Trans., v. 1, p. 109, pl. 15, fig. 45.

Lyria musicina Heilprin. DALL, 1890, Wagner Free Inst. Sci., Trans., v. 3, pt. 1, p. 85 (in part).

Lyria musicina Heilprin. DALL, 1915, U.S. Natl. Mus., Bull. 90, p. 59; in part, *not* pl. 9, figs. 1, 4

PLATE 5

Figures Page

1, 2. *Falsilyria pycnopleura* (Gardner) (x 1-1/2) 126

1. USNM 258143; height 43.3 mm, diameter 19.8 mm.
Locality: TU 457, Chipola River. Chipola Fm., late lower Miocene.
(Fig. 1c X 10)

2. USNM 253229; height 45.0 mm, diameter 19.6 mm.
Locality: TU 546, Ten Mile Creek. Chipola Fm., late lower Miocene.

3. *Falsilyria vaughani* (Cooke) (x 2) 128
USNM 166955 (holotype); height 20.6 mm, diameter 12.0 mm.
Locality: Crocus Bay, Anguilla, B.W.I. Anguilla Limestone, (?) upper Miocene.

4, 5. *Falsilyria anoptos,* n. sp. (X 1-1/2) 127

4. USNM 253228 (holotype); height 44.7 mm, diameter 20.7 mm.
Locality: TU 555, Chipola River. Chipola Fm., late lower Miocene.
(Fig. 4c X 10).

5. USNM 258144 (paratype); height 25.8 mm, diameter 12.3 mm.
Locality: TU 555, Chipola River. Chipola Fm., late lower Miocene.

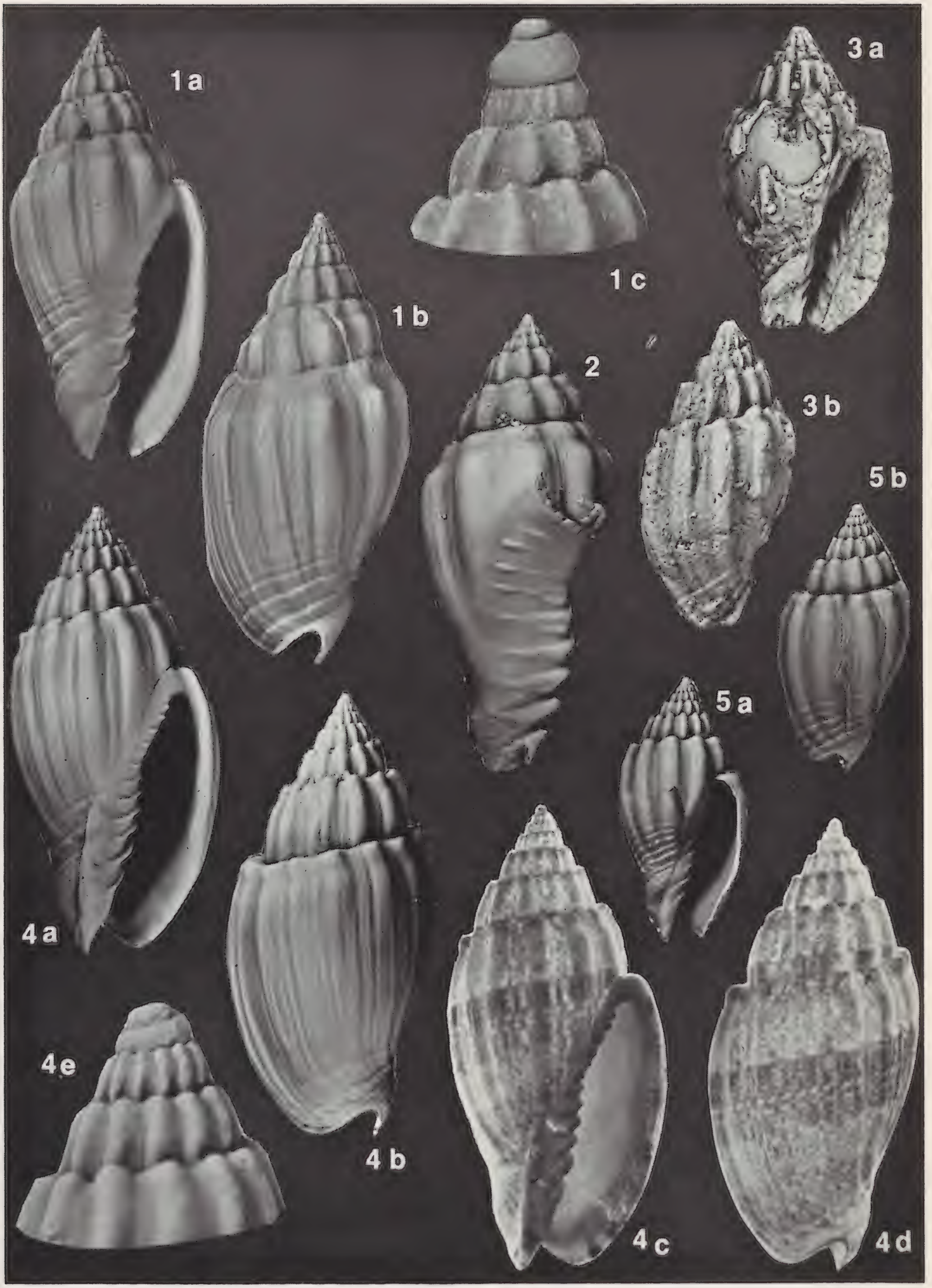

PLATE 5

= *Falsilyria pycnopleura* (Gardner).

Lyria musicina (Heilprin). COOKE and MOSSOM, 1929, Florida Geol. Surv., Ann. Rept. 20, p. 85 (list); *not* pl. 8, fig. 6 (after Dall, 1915, pl. 9, figs. 1, 4) = *Falsilyria pycnopleura* (Gardner).

Lyria musicina (Heilprin). MANSFIELD, 1937, Florida Geol. Surv., Bull. 15, p. 105, pl. 3, figs. 1, 4.

Diagnosis: "Shell cylindriform; spire elevated, of about seven volutions; whorls convex, strongly costated, impressed below the suture, so as to divide the costae into a double series; costae very prominent, obtuse, about ten on the body-whorl, crossed at right angles by rather distantly-placed elevated revolving lines; outer lip with a reflected border; inner lip distinct in its lower half, plicated over its entire extent, the plicae increasing in size from above downward, nearly transverse in direction; aperture considerably over half the length of shell, narrow." (Heilprin, 1887)

Dimensions of holotype: "Length, nearly two inches; greatest width, at about the middle of the shell, slightly exceeding one inch." (Heilprin, 1887)

Holotype: Wagner Free Institute of Science, Philadelphia.

Type locality: Ballast Point, Tampa Bay, Hillsborough County, Florida.

Occurrence: Tampa Limestone, Florida; early lower Miocene.

Figured specimen: USNM 112106, height 42.3 mm, diameter 21.8 mm; locality, Ballast Point, Tampa Bay, Hillsborough County, Florida.

Discussion: Falsilyria musicina retains some *Lyria* characteristics, such as the narrow nucleus, and the slender-appearing columella, with only a slight suggestion of broadening on the anterior half. The *Voluta* characteristics are shown by the five heavy columellar plications, beveled edge of the outer lip, well-developed siphonal fasciole, and deep narrow siphonal notch.

FALSILYRIA PYCNOPLEURA (Gardner)

Plate 5, figs. 1, 2

Lyria musicina Heilprin. DALL, 1915, U.S. Natl. Mus., Bull. 90, p. 59, pl. 9, figs. 1, 4. (*Not* of Heilprin.)

Lyria musicina (Heilprin). COOKE and MOSSOM, 1929, Florida Geol. Surv., Ann. Rept. 20, pl. 8, fig. 6 (after Dall, 1915).

Lyria pycnopleura GARDNER, 1937, U.S. Geol. Surv., Prof. Paper 142-F, p. 404, pl. 48, figs. 1, 2.

Falsilyria pycnopleura (Gardner). PILSBRY and OLSSON, 1954, Bulls. Amer. Paleontology, v. 35, no. 152, p. 21, pl. 3, fig. 1.

Falsilyria pycnopleura (Gardner). OLSSON, 1965, Bulls. Amer. Paleontology, v. 49, no. 224, p. 665, pl. 83, fig. 8.

Diagnosis: "Shell heavy, solid, rather large, attaining an altitude in one individual of 63.0 millimeters. Spire moderately elevated in the type, one-third of the altitude of the entire shell, turriculated, the whorls of the spire narrowly tabulated behind, the sides trapezoidal, their outline obscured, however, by the heavy axial ribbing. Body ovate, not sharply constricted at the base. Whorls of conch usually 6, in the larger individuals, 7. Protoconch of moderate dimensions and performing between 2 and 2-1/2 volutions; initial turn of protoconch strongly and smoothly rounded, immersed at the tip, the succeeding turn becoming increasingly flattened laterally toward the close of the protoconch. Opening of conch marked only by the introduction of the axial ribbing and not by any perceptible change in the contour of the shell. Costals upon the early volutions narrow, sharply and prominently elevated; cordate ridges uniform in elevation throughout their extent, terminating abruptly at the posterior suture, thus forming an obscurely defined sutural corona; axials normally 10 to each whorl not including the terminal varix, the axials upon the later volutions broader and more broadly rounded than upon the earlier and much lower and inclined to be less regularly spaced upon the last turn of the body. Spiral sculpture restricted to 2 or 3 ridges at the base of the body, and obscure threading upon the fasciole and a very obscure groove a little before the posterior suture, which partly dissects the axials. Sutures deeply impressed, crenulated by the costae of the preceeding volution. Aperture narrow, obtusely angulated at the posterior commissure. Outer lip approximately straight medially, curving anteriorly into the terminal notch, posteriorly produced for a short distance, dragging the suture about one-fourth of the way across the penult. Marginal varix narrow but rather heavy; inner surface of labrum thickened but smooth. Inner margin of the aperture feebly constricted by the curvature of the body. Parietal wall heavily glazed, the callus extending in a wide arcuate area between the extremities of the aperture, heaviest anteriorly; transversely lirate with 3 or 4 fine but rather sharp, commonly broken lirae approximately parallel to the labial plications in front of them but not persistent far within the aperture. Columella folds usually 6, the posterior approximately horizontal, the anterior, especially the foremost, slightly oblique; fold broadest and most prominent just at the entrance to the aperture, evanescing externally. Siphonal fasciole strongly arched, incrementally striated, cut off from the base of the body by a shallow sulcus. Anterior canal incipient, the extremity profoundly emarginate, the walls parallel and obliquely directed." (Gardner, 1937)

Dimensions of holotype: height 39.0 mm, diameter 18.5 mm.

Holotype: USNM 328729.

Type locality: USGS 3419, one mile below Bailey's Ferry, Chipola River, Calhoun County, Florida (= TU 457).

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 1, USNM 258143; height 43.3 mm, diameter 19.8 mm; locality TU 457. Fig. 2, USNM 253229; height 45.0 mm, diameter 19.6 mm; locality TU 546. Other occurrences; TU locality nos. 458, 459, 547, 554, 555, 820, 821, 825, 830, 950, 951, 998, 999, 1048, 1196.

Discussion: Falsilyria pycnopleura is a descendant of the Tampa species, *F. musicina.* Although they were confused by Dall (1915, p. 59) the two species are distinct. Both have the subsutural groove crossing the axial ribs, but the spiral sculpture of *F. pycnopleura* is confined to the basal area of the shell and the spire is consistently higher than that of the Tampa species of *Falsilyria.* The Chipola species shows a stronger affinity toward the genus *Voluta* as demonstrated by its broader nucleus, greater widening of the anterior half of the columella, and coarser columellar lirations and plications (see pl. 5, fig. 2).

Falsylyria pycnopleura is a common species occurring throughout the Chipola Formation, particularly along the Chipola River and Farley Creek.

FALSILYRIA ANOPTOS, n. sp.
Plate 5, figs. 4, 5

Diagnosis: Shell large, heavy; seven teleoconch whorls in adult; plus a nucleus of one and one-half smooth, bulbous whorls. Eleven or twelve rounded axial ribs, becoming flattened and evanescent in the adult. Suture slightly channeled by coronated terminations of axial ribs. Aperture elongate, outer lip only slightly thickened by the terminal rib and bearing very faint paired denticulations, which in life corresponded to dashes of color. Columella lightly glazed, bearing ten to twelve plications, three anteriormost the strongest and most oblique, becoming weaker and more horizontal toward posterior end. Spiral ornament of three to six flattened ridges at the base of the body whorl and an obscure groove in advance of the suture. Weak siphonal fasciole; anterior canal gently recurved.

Dimensions of holotype: height 44.7 mm, diameter 20.7 mm.

Holotype: USNM 253228.

Type locality: TU 555, east bank of Chipola River, about 1000 feet above Four Mile Creek (SW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

Paratype: USNM 258144; height 25.8 mm, diameter 12.3 mm; locality TU 555.

Occurrence: Chipola Formation, Florida; late lower Miocene.

Figured specimens: Fig. 4, USNM 253228 (holotype). Fig. 5, USNM 258144 (paratype). Other occurrence: TU locality no. 547.

Discussion: In the coral-reef facies of the Chipola Formation (TU localities 547, 555) there is a second species of *Falsilyria* that occurs together with *F. pycnopleura.* Although similar in appearance the new species may be distinguished by having the subsutural groove less pronounced, the suture more impressed and the axial ribs slightly coronated in the manner of *Harpeola.* But even more importantly the two protoconchs are different: that of *F. pycnopleura* is of two and one-half large whorls (1.5 mm approximate diameter); that of the new species is only one and one-half whorls and smaller (1 mm approximate diameter). The color patterns of the two species are identical and that of *F. anoptos* is here figured (pl. 5, figs. 4c, 4d). This pattern is similar to that of the Recent *"Voluta" demarcoi* Olsson, from off El Mezquital, Tamps., Mexico (Olsson's citation of "Texas" is an error). Although named as *Voluta* by Olsson (1965, p. 663), from the nature of the columellar plications (about 14 in number) and the subsutural constriction (well shown in Olsson's pl. 82, fig. 1c) it seems obvious that the species is better referred to *Falsilyria,* and as such is the first known Recent example of the genus.

Gardner (1937, p. 404) compared *F. pycnopleura* with the Caribbean *"Lyria" vaughani* Cooke but the latter is more closely akin to this new species. From *F. vaughani, F. anoptos* differs in having more axial ribs per whorl and in having the spiral sculpture at the base of the body whorl more strongly developed. On the basis of a single specimen of *F. vaughani* it is not certain, but the size of the Chipola species also seems to be greater. The holotype of *F. vaughani* is 22 mm in height but our largest example of *F. anoptos* measures 47 mm (TU 547) and is comparable in size to *F. pycnopleura.*

Falsilyria vaughani and *F. anoptos* show many similarities to the subgenus *Lyria (Harpeola)*. Both have slightly coronated axial ribs, which cause the suture to be channeled, and *F. anoptos* shows very faint labral denticulations akin to those of *Harpeola.* However, the color dashes that correspond to these color lines (see pl. 5, fig. 4c) are paired, as in the genus *Voluta* s.s., rather than single as in *Harpeola anna.* In fact, the entire color pattern is most like that of *Voluta* s.s. reinforcing our opinion that *Falsilyria* is a northern offshoot of the *Voluta* lineage.

In contrast to the commonly occurring *F. pycnopleura,* this new species is relatively rare (less than a dozen specimens) and is confined to only two localities in the coral-reef facies of the Chipola Formation. As the early collections from the Chipola had no material from these localities it is understandable that the species as remained unkown until this time, hence the name *anoptos* (Greek – "unseen").

FALSILYRIA VAUGHANI (Cooke)
Plate 5, fig. 3

Lyria vaughani COOKE, 1919, Carnegie Inst. Washington, Publ. 291, p. 111, pl. 1, fig. 4.

Lyria vaughani Cooke, GARDNER, 1937, U.S. Geol. Surv., Prof. Paper 142-F, p. 404.

Diagnosis: "Shell volutiform, spire high; nucleus small, succeeded by 5 whorls with high narrow axial costae, about 9 on the body whorl, near the anterior extremity of which are several oblique threads; aperture wide, about two-thirds the length of the shell; pillar lip with 3 basal folds and apparently several indistinct folds and an elliptical node at the posterior end; anterior canal short, with an oblique fasciole." (Vaughan, 1919)

Dimensions of holotype: height 20.6 mm, diameter 12.0 mm.

Holotype: USNM 166955.

Type locality: Crocus Bay, Anguilla, British West Indies.

Occurrence: Anguilla Limestone, Anguilla, B.W.I.; (?)upper Miocene.

Figured specimen: USNM 166955 (holotype).

Discussion: Cooke (1919, p. 108) considered the beds on Anguilla, from whence came this species, as Oligocene in age, stating: "The fossil horizon of Anguilla is evidently intermediate in age between the Oligocene deposits at Bainbridge and the Bowden marl, and its stratigraphic position is probably not far from that of the Tampa limestone of Florida." However, the presence of *Spondylus bostrychites* Guppy and *Orthaulax aguadillensis* Maury* (identified as *O. pugnax*) in these beds indicates that a younger age is more likely. According to Eames *et al.* (1962, fig. 5) the Anguilla Limestone is correlated with the Los Puertos Limestone of Puerto Rico, a formation that is now dated as upper Miocene by Seiglie and Moussa (1975, p. 2315).

Gardner (1937, p. 404) compared her species *"L." pycnopleura* with *"L." vaughani* and noted that the Anguillan species was smaller, with differences in the sculptural details. The holotype of *"L." vaughani* is poorly preserved, the aperture is almost obliterated by matrix and details are obscured. Three strong columellar plications may be observed at the anterior end but no more. The suture is impressed and the subsutural groove is strong. The ribs are coronated almost to the point of resembling a *Harpeola,* but comparison with the specimen of *F. anoptos,* n. sp., here figured (pl. 5, fig. 4) shows this is not confined to that group. Although the aperture appears to have a posterior sulcus this is due to the breaking of the aperture at an axial rib.

V. LOCALITY DATA

The following are Tulane University fossil locality numbers:

226. Red Bluff Clay, Chickasawhay River at Hiwannee, 3-1/2 miles south of Shubuta (Sec. 28, T10N, R7W, St. Stephens Base and Meridian), Wayne Co., Mississippi.
335. Byram Marl, roadcut on U.S. Highway 61 (Business) about one mile north of Vicksburg Natl. Military Cemetery, Vicksburg, Warren Co., Mississippi.
457. Chipola Fm., west bank of Chipola River, about 1/2 mile below Ten Mile Creek (SW 1/4 Sec. 17, T1N, R9W), Calhoun Co., Florida.
458. Chipola Fm., east bank of Chipola River

**Orthaulax aguadillensis* Maury is found in beds that are now determined to be upper Miocene and Pliocene in age, making the species much younger than previously thought. This will be discussed further in a forthcoming paper by E. H. Vokes.

above Farley Creek (SW 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.

459. Chipola Fm., east bank of Chipola River, steep bank about 1500 feet above the mouth of Taylor Lake Branch (NW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

546. Chipola Fm., Ten Mile Creek, about 1-1/2 miles west of Chipola River (NW 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

547. Chipola Fm., west bank of Chipola River, about 2000 feet above Four Mile Creek (SW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

554. Chipola Fm., east bank of Chipola River at power line crossing (SW 1/4 Sec. 17, T1N, R9W), Calhoun Co., Florida.

555. Chipola Fm., east bank of Chipola River, about 1000 feet above Four Mile Creek (SW 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

562. "Silverdale beds", Onslow County marl pit, on south side of Webb Creek, near Silverdale, Onslow Co., North Carolina.

704. "Silverdale beds", Gillette's Marl Pits (old pit) 1/3 mile from junction of roads to Stella and Swansboro at Silverdale, North Carolina.

757. Gatun Fm., roadcut on south side of Boyd-Roosevelt Highway at junction of road to "Refineria Panamá, S.A.", just east of Cativa, Prov. of Colón, Panamá.

820. Chipola Fm., Farley Creek (lower beds), at bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

821. Chipola Fm., Farley Creek, 0.1 mile east of bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

825. Chipola Fm., Farley Creek, at abandoned mill about 1/4 mile west of bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

830. Chipola Fm., Ten Mile Creek, at power line crossing about one mile west of Chipola River (SE 1/4 Sec.. 12, T1N, R10W), Calhoun Co., Florida.

866. "Silverdale beds", marl pit on north side of Webb Creek and east side of unnumbered county highway, Silverdale, Onslow Co., North Carolina.

950. Chipola Fm., Chipola River, west bank, about 200 feet above Farley Creek (SW 1/4 Sec. 20, T1N, R9W), Calhoun Co., Florida.

951. Chipola Fm., Ten Mile Creek, about 1-1/4 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

998. Chipola Fm., Ten Mile Creek, about 1-1/4 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun Co., Florida.

999. Chipola Fm., Farley Creek, about 1000 yards downstream from bridge of Florida Highway 275 (SW 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

1048. Chipola Fm., Farley Creek, south bank, about 0.8 miles east of bridge of Florida Highway 275 (NE 1/4 Sec. 21, T1N, R9W), Calhoun Co., Florida.

1196. Chipola Fm., Farley Creek, north (=NW) bank about 1/2 between 1048 and 1049, or about 0.8 mi. east of bridge on Florida Highway 275 (NE 1/4 Sec. 29, T1N, R9W), Calhoun Co., Florida.

1210. Gurabo Fm., Rio Gurabo, east bank, first bluff below bridge on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8544; Maury's Zone B).

1211. Gurabo Rm., Rio Gurabo, west bank, second bluff below the bridge on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8546).

1212. Gurabo Fm., Rio Gurabo, east bank, third bluff below the bridge on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8548).

1213. Gurabo Fm., Rio Gurabo, east bank, fourth bluff below the bridge on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8549).

1214. Gurabo Fm., Rio Gurabo, fifth (= USGS 8550), sixth (= USGS 8551), seventh (= USGS 8552), and eighth (= USGS 8553) bluffs on both sides of river below the bridge on the road from Los Quemados to Sabaneta, Dominican Republic.

1215. Gurabo Fm., bluffs on both sides of Rio Gurabo, from the bridge upstream to approximately one km above the bridge, on the road from Los Quemados to Sabaneta, Dominican Republic (= USGS 8539+8543; Maury's Zone D).

1219. Gurabo Fm., Rio Amina, bluffs on east side of river, just above the ford, which is 2 kms west of Potrero, and about 3 kms downstream from "La Represa", Dominican Republic (= USGS 8516).

1227. Gurabo Fm., deep arroyo, which crosses the road to Jánico from Santiago de los Caballeros, 11 kms south of the bridge over Rio Yaque del Norte, at Santiago, Dominican Republic.

1246. Gurabo Fm., Rio Gurabo, from 1 km to 2 kms (airline) upstream from bridge on Los Quemados-Sabaneta road, Dominican Republic (= USGS 8538).

1248. Gurabo Fm., Rio Amina, first bluff downstream from ford at Potrero, on west side of river, Dominican Republic.

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COMMENTS ON SUBFAMILIAL RELATIONSHIPS IN TWO AMPHI-AMERICAN MURICID GENERA – *ACANTHOTROPHON* AND *ATTILIOSA*

GEORGE E. RADWIN and ANTHONY D'ATTILIO
NATURAL HISTORY MUSEUM
SAN DIEGO, CALIFORNIA

Vokes (1976) has treated the Recent and fossil species of the genus *Attiliosa* extensively, especially as they occur in the western Atlantic. A reading of that paper has caused us to reassess the subfamilial assignments of two of the Recent western Atlantic species and their relationships to two or more eastern Pacific species.

Generic and subfamilial assignments have long had a problematical status in the family Muricidae. This is almost certainly due to the extensive degree of apparent shell-morphological convergence found in the family as a whole and, in particular, among certain groups. One of these groups is the Trophoninae, although our use of this name should not be taken as an acceptance of the validity of such as a cohesive subfamily group. As has been noted by several authors (Radwin and D'Attilio, 1976; Vokes, 1976; Radwin, 1977), groups cited under this name in the literature are virtually all polyphyletic. Vokes *(Op. Cit.,* p. 118, 120) has persuasively expressed the view that the type species of *Trophon (Buccinum geversianum* Pallas) and its close relatives are phylogenetically distinct from northern hemisphere "Trophoninae," which she believes are derived from a *Poirieria*-like ancestor. This latter group may itself be polyphyletic, containing within it (according to Vokes and others) such diverse genera as *Acanthotrophon* Hertlein and Strong, 1951; *Ergalatax* Iredale, 1931; *Lataxiena* Jousseaume, 1883; *Nipponotrophon* Kuroda and Habe, 1971; *Paziella* Jousseaume, 1880; *Pazinotus* E. H. Vokes, 1970; and *Poirieria* Jousseaume, 1880, as well as seemingly more typical trophonoid genera such as *Boreotrophon* Fischer, 1884; *Trophonopsis* Bucquoy and Dautzenberg, 1882; *Pagodula* Monterosato, 1884; and *Actinotrophon* Dall, 1902.

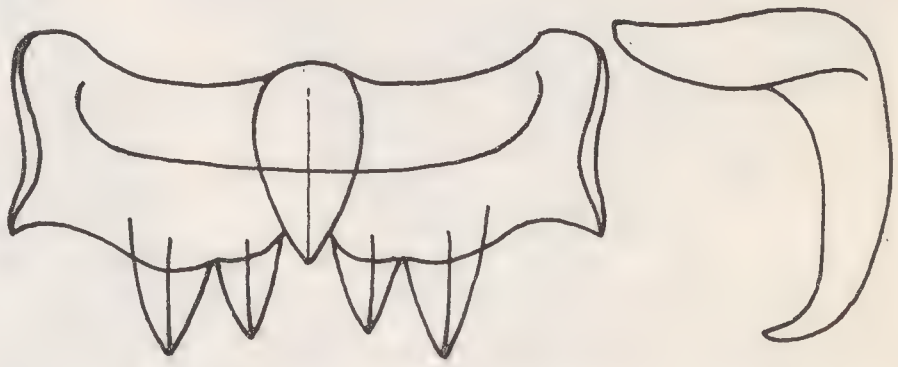


Figure 3a. *Acanthotrophon sentus* Berry; Sonora, Mexico.

In our recently published book on the Muricidae (Radwin and D'Attilio, 1976), a specimen we figured (pl. 3, fig. 10) as *Attiliosa philippiana* (Dall, 1889) is not that species. The type lot of *A. philippiana* contains two specimens and, as Vokes points out, the two represent distinct species. She figured the appropriate lectotype (1976, pl. 8, fig. 12) as seen in the original illustration (Dall, 1902, pl. 29, fig. 5). The other syntype represents one of a large number of forms of *"Muricidea" striata* Gabb, 1873 (figs. 1, 2), based on a fossil from the Miocene of the Dominican Republic, which is living today in the western Atlantic. Studying the varying shell forms of this species, as illustrated by Vokes, we were struck with the fact that only very few of these could be

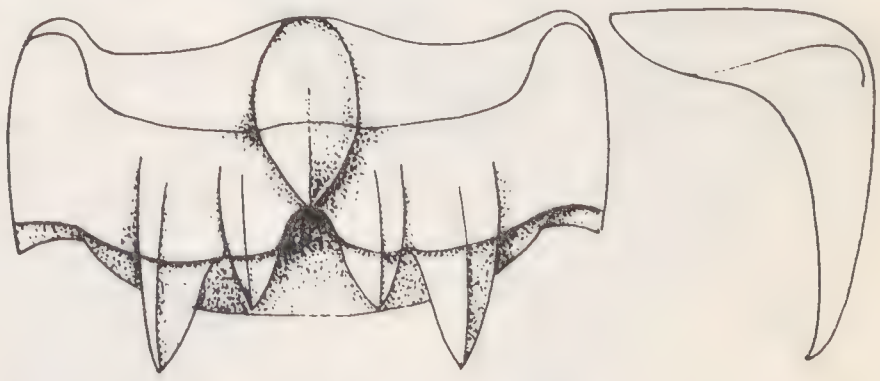


Figure 4a. *Acanthotrophon carduus* (Broderip); Sta. Cruz, Galápagos Islands.

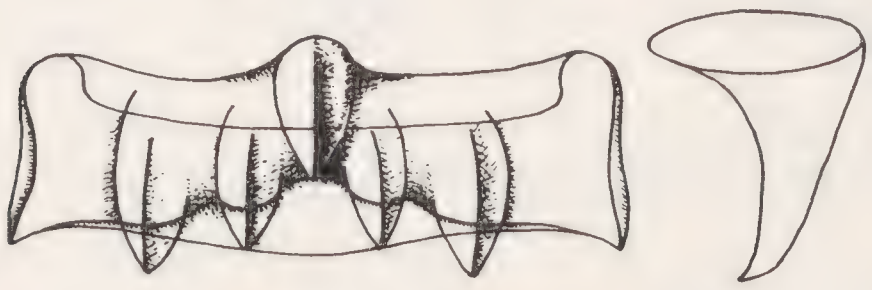


Figure 1a. *Acanthotrophon striatus* (Gabb); Naples, Florida.

easily confused with *A. philippiana* (fig. 6) and that the latter species, although known from only a small number of specimens, seems to be conservative in shell morphology. Coincidentally, a cognate species, similar in most respects to *A. philippiana* occurs in the eastern Pacific. This is *Attiliosa nodulosa* (A. Adams, 1855)* (fig. 5), the type of the genus.

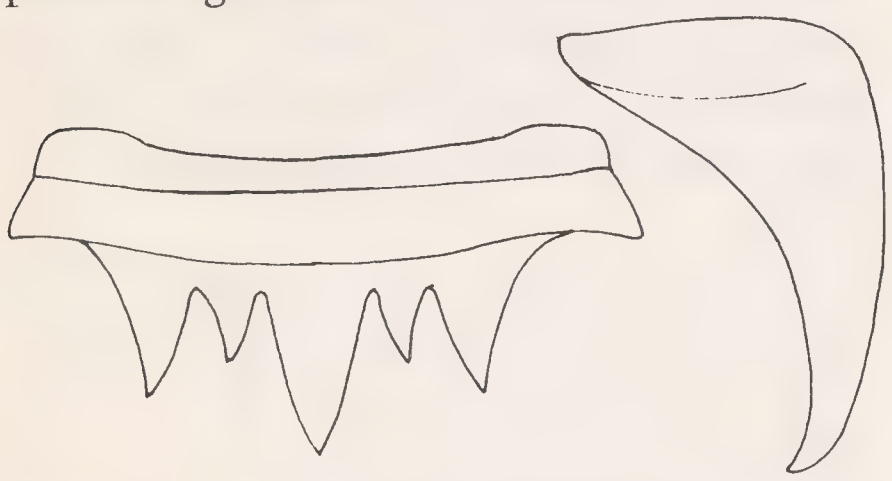


Figure 5a. *Attiliosa nodulosa* (Adams); Angel de la Guardia, Mexico.

As Vokes noted, the eastern Pacific also has a complex of forms (or species) that is comparable to the *"Attiliosa" striata* complex of the western Atlantic. These generally have been assigned to the genus *Acanthotrophon* Hertlein and Strong, 1951. Names applied to members of this complex include *Acanthotrophon carduus* (Broderip, 1833) (fig. 4), *A. sentus* Berry, 1969 (fig. 3) and *A. sorenseni* Hertlein and Strong, 1951, the type of the genus. Whether these are each distinct species or, as in the case of the *A. striata* complex, all forms of a variable species, these Panamic forms are remarkably similar to several examples of *A. striata* that are illustrated by Vokes.

Although we have long believed that in the Muricidae congeneric species cannot be distinguished from each other on the basis of their radular dentitions, our radular studies have indicated a considerably discrepency between the radular dentitions of *Acanthotrophon* species and those generally assigned

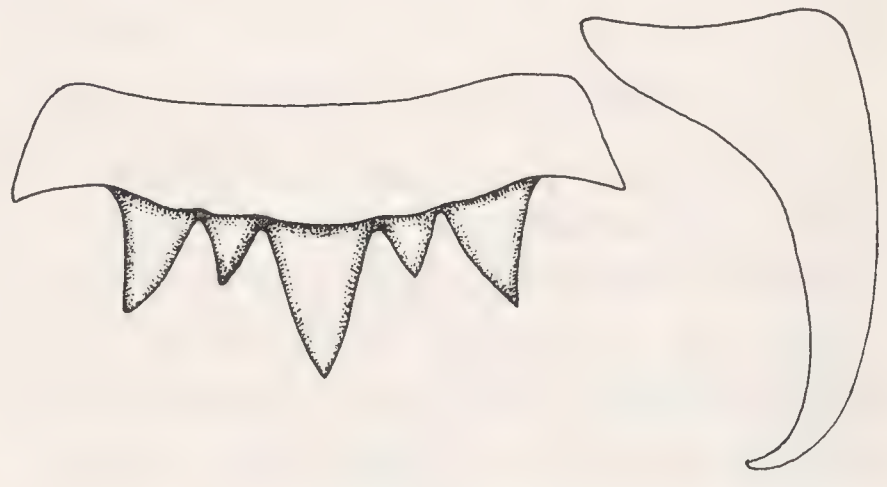


Figure 6a. *Attiliosa phillippiana* (Dall); Cabo Catoche, Mexico.

to *Attiliosa.* We had indicated previously a muricine placement for *Acanthotrophon,* but now, on the basis of new studies of the radulae of *Acanthotrophon* species from the eastern Pacific (figs. 3a, 4a) and of *Acanthotrophon striatus* (fig. 1a), for this we believe to be its correct generic placement, we feel that this genus must be reassigned to the muricid subfamily Muricopsinae. The radular dentition of the true *Attiliosa* species (figs. 5a, 6a, 7) are so typically muricine that, in this case, we can separate species by distinguishing between genera that are, in turn, assignable to different muricid subfamilies.

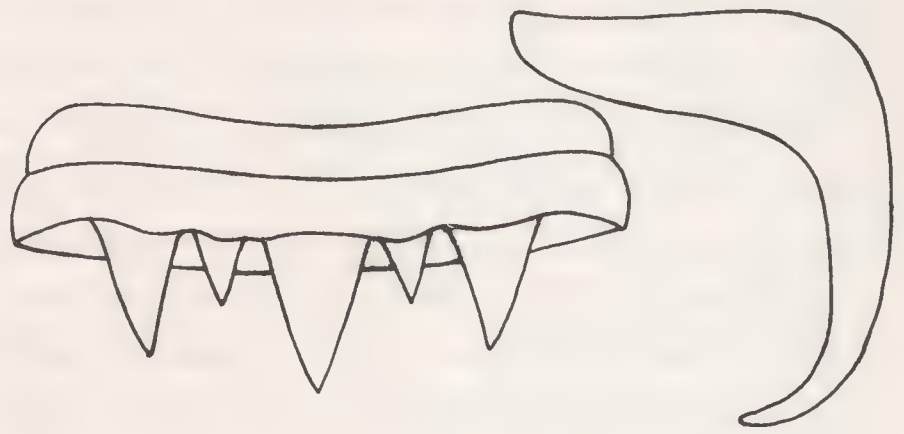
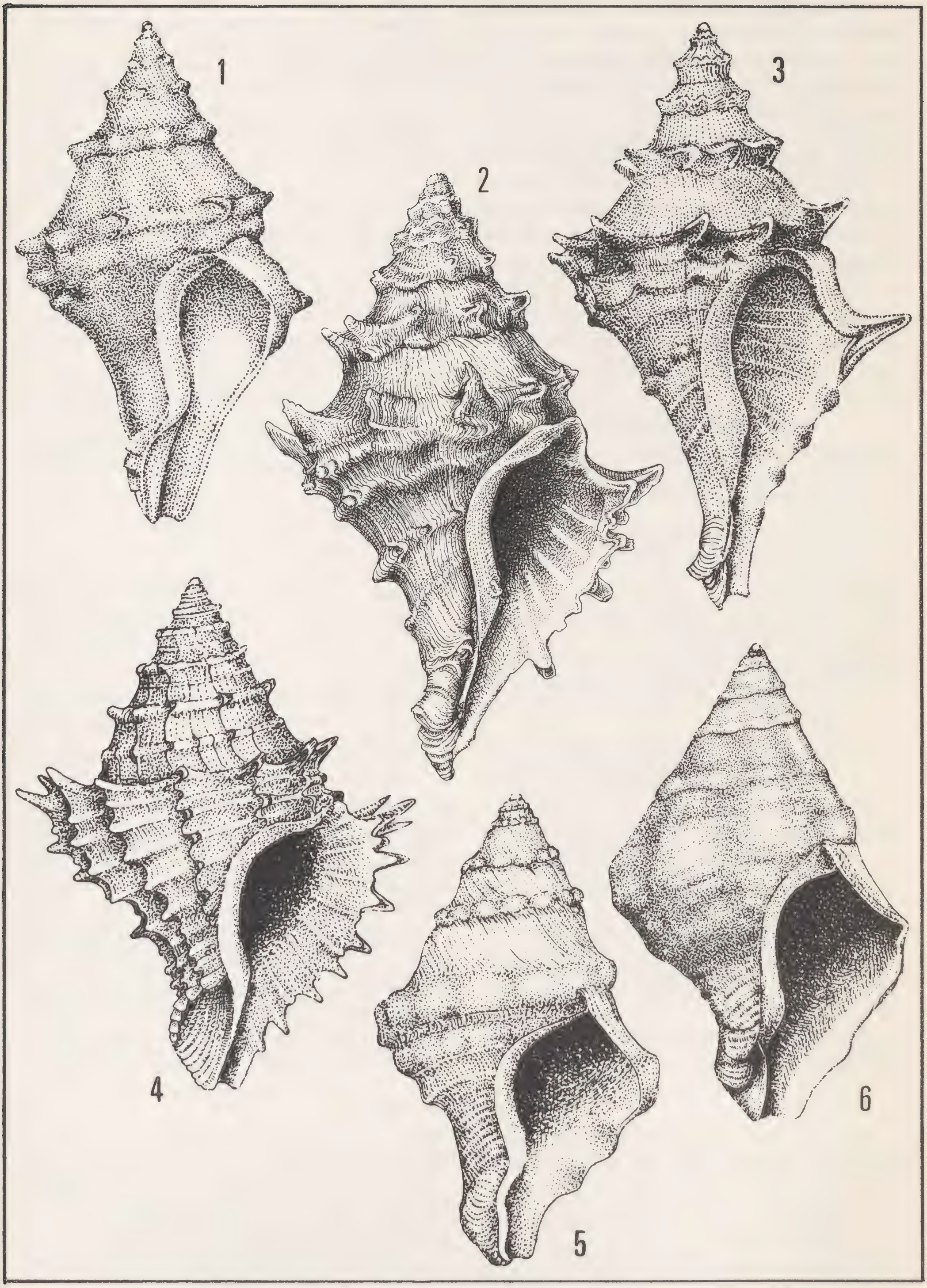


Figure 7. *Attiliosa aldridgei* (Usticke); La Panguera, Puerto Rico.

*Formerly *A. incompta* Berry, 1960, see Bullock, 1976.

Figure

1. *Acanthotrophon striatus* (Gabb); Naples, Florida (X4)
2. *Acanthotrophon striatus* (Gabb); TU 1240, Moín Formation. Pleistocene; Puerto Limon, Costa Rica (X4)
3. *Acanthotrophon sentus* Berry; Sonora, Mexico (X4)
4. *Acanthotrophon carduus* (Broderip); Mazatlan, Mexico (X3)
5. *Attiliosa nodulosa* (Adams); Angel de la Guardia, Mexico (X3)
6. *Attiliosa phillippiana* (Dall); Cabo Catoche, Mexico (Lectotype) (X5)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To summarize: In both the western Atlantic and the eastern Pacific there is at least one Recent species of *Attiliosa* (in fact, the western Atlantic has two: *A. philippiana* and *A. aldridgei*). In each case the shell morphology is comparatively constant and the radular dentition indicates a firm placement in the Muricinae. In both the western Atlantic and the eastern Pacific there is also a complex series of subtly variable forms grading one into another, some convergent in shell morphology with the *Attiliosa* species. These complexes are assignable to *Acanthotrophon* and have radular dentitions that clearly show muricopsine characteristics.

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EDITOR'S NOTE

The preceeding paper was left uncompleted by George E. Radwin at the time of his premature death in September, 1977. Mr. D'Attilio requested that I see the manuscript through publication and I was happy to comply. The ideas expressed are those of Radwin and the illustrations are by D'Attilio. I am responsible for the final draft and any typographical errors that may have slipped by. The specimen from Moín, Costa Rica, shown in figure 2, was collected by me after Dr. Radwin's death. It is included because it demonstrates the validity of his observations on the similarities between the Pacific *"carduus-sentus-sorensoni"* complex and the Atlantic *"striatus"* complex. They probably all should be referred to the same species for which *Acanthotrophon carduus* (Broderip) would be the oldest name.

Emily H. Vokes

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A PLEISTOCENE OSTRACODE FAUNA FROM SOUTH FLORIDA

MERVIN KONTROVITZ
RIDER COLLEGE, LAWRENCEVILLE, NEW JERSEY

CONTENTS

Page
I. ABSTRACT 135
II. INTRODUCTION 135
III. THE SEDIMENT 136
IV. AGE OF THE SEDIMENT 136
V. PALEOENVIRONMENT 136
VI. ACKNOWLEDGMENTS 137
VII. SYSTEMATIC PALEONTOLOGY 137
VIII. LOCALITY DATA 156
IX. LITERATURE CITED 156

ILLUSTRATIONS

TABLE 1: Ostracode faunal list 138
PLATE 1 147
PLATE 2 149
PLATE 3 151
PLATE 4 153
PLATE 5 155

I. ABSTRACT

A Pleistocene ostracode fauna with 41 species was recovered from carbonate sediments that occur in Palm Beach County, Florida. The fauna is described and three new species are named; these are *"Aurila" bellegladensis, Megacythere edwardsi* and *Hemicytherura vokesae.* Ostracode occurrence data and petrological evidence indicate that the sediments were deposited under fully marine conditions at a water depth of from 0 to 23 meters and in a tropical or subtropical climate regime.

II. INTRODUCTION

Ostracode remains were recovered from Pleistocene sediments located near the town of Belle Glade in Palm Beach County, Florida. Five samples were examined, three of which were collected at Tulane University Locality 201 (TU 201) and one each from localities TU 580 and TU 733 (see Section VIII for description). Four of the five samples were washed before they were received by the author. The unwashed sample (from TU 201) was analysed for grain size distribution and composition.

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ROGER L. KAESLER, University of Kansas, Lawrence, Kansas
PAUL R. KRUTAK, University of Nebraska, Lincoln, Nebraska
PAGE VALENTINE, U.S. Geological Survey, Woods Hole, Massachusetts

Two of the samples (TU 580 and TU 733) contained only juvenile valves, fragments of large species and complete valves and carapaces of small species (less than .55 mm in length). Inasmuch as all washed samples were prepared in the same manner, the samples containing only small specimens and fragments are interpreted as representing the results of differential transportation of the original material.

III. SEDIMENT ANALYSIS

The sample (from TU 201) used for lithologic analysis (379.2 grams) was a very light gray shell marl. More than 90% of the sediment grains were in the size range of 0.074 to 20.0 mm, that is, fine sand and larger. Those grains larger than 0.420 mm were whole or broken fossils.

The total carbonate fraction, 86.2% by weight, was composed chiefly of bivalves, gastropods, echinoid spines, bryozoa and coral fragments. The other material was insoluble residue composed of quartz (90%) and minor quantities of clay minerals, organic matter and a few dark mineral grains. The quartz grains were mostly angular or subangular with a few being subrounded or rounded.

Using Folk's classification (1962) for such materials, the sediment is categorized as a lime mud with fossils; it is the Type II carbonate composed of allochems and micrite. Conditions of short-lived currents or a rapid rate of formation of the microcrystalline ooze are thus indicated. The sediments may be placed in the Type II class of Plumley *et al.* (1962), which represents deposition in waters that were alternately quiet and agitated.

IV. AGE OF THE SEDIMENT

The stratigraphy of the region has been reviewed by Olsson *(in* Olsson and Petit, 1964), who concluded that the "Caloosahatchee Formation" of earlier workers was comprised of several units that should be described separately. The uppermost of the units was designated by Olsson to be "Unit A" (*ibid,* p. 521) and is the source of the material used in the present study. Olsson indicated that "the unit is referred to the late Pliocene, but an early Pleistocene age is also possible" (*ibid,* p. 525).

Emily H. Vokes (1973, personal communication) stated that "Unit A" is of Pleistocene age; this conclusion is based upon her studies of the molluscan faunas and their relationships to the Moín Formation of Costa Rica. Akers (1972) also indicated that the Moín Formation is of Pleistocene age. DuBar (1974) suggested that "Unit A" of Olsson was of a "medial Pleistocene age" and he informally proposed the name "Bermont Formation" for the unit.

Qualitative and quantitative comparisons (Cheetham and Hazel, 1969) to other nearby Pleistocene ostracode faunas are of little use in the determination of the exact age of the "Bermont Formation." That is, there are so few similarities at the species level that the results are inconclusive in an attempt to delineate which portion of the Pleistocene record is represented (see Hall, 1965; Hazel, 1968; Valentine, 1971).

V. PALEOENVIRONMENT

A summary of environmental conditions of modern representatives of fossil species is given in the systematics portion of this paper. It is not possible to compare the fauna directly with assemblages from nearby modern localities because there are few species in common with any single living assemblage (Puri, 1960; Benson and Coleman, 1963; Keyser, 1975). The closest relationships exist between this fauna and those from the Florida Keys-Florida Bay area. For example, 10 of the 14 species reported by Puri (1960) from the Keys are present in the "Bermont" material, but only 15 of Puri's 40 species from Alligator Point were recovered. This may indicate that differences in sediment characteristics are strongly reflected in the composition of faunal assemblages.

Based upon the modern occurrences of the ostracode species of the Belle Glade area the salinity range at the time of deposition ranged from 25 to 40 o/oo. About one-half of the species that occur in modern sediment (15 of 29) are normally found under such

conditions, while most of the other forms have been reported only from marine waters.

The species restricted to fresh or brackish waters comprise less than 5% of the total valve count. *Limnocythere* sp. and *Physocypria pustulosa* were probably transported from areas with relatively lower salinity to an area that was polyhaline or ultrahaline (Ager, 1963) or those specimens represent contamination from the overlying fresh water sediments (McGinty, 1970). *Paracytheridea vandenboldi* has been reported from only brackish water but its modern occurrence has been noted in only one study (Swain, 1955) therefore its total range is probably not known. Other taxa present in the assemblage from Belle Glade have been reported only from marine environments; these include *Bairdoppilata, (Bairdoppilata) cushmani, Loxocorniculum fischeri, Loxocorniculum postdorsolatum, Orionina bradyi, Paracypris sablensis, Paranesidea bradyi, Proteoconcha multipunctata,* and *Protocytheretta pumicosa.* The marine ostracode species indicate the same environment represented by the "Molluscan 'Glades' fauna" mentioned by McGinty (1970).

Some of the previous publications on modern ostracodes do not present exact information on water depth of sample sites, but it is usually possible to interpret the approximate depth range of a particular species. In the present study, if *Physocypria* and *Limnocythere* are eliminated from consideration, the remaining taxa are indicative of depths from near the shoreline to 23 meters. It is a depth range that the reported species have in common, that is, an interval in which all the species sometimes occur.

The marine climate is interpreted as having been subtropical or tropical. *Cyprideis mexicana, Cytherura* sp. C and *Xestoleberis rigbyi* have been reported only from tropical regions, whereas *Cyprideis salebrosa, Loxoconcha fischeri* and *Paracytheridea vandenboldi* have been reported only in subtropical areas. It should be noted that the species mentioned above are recorded in few papers dealing with modern sediments; the total of such environmental range of each species may not be known. All remaining species reported from modern sediments have been recovered from both subtropical and tropical areas. The climatic terms are used as proposed by Trewartha (1954) and Rumney (1968) and are based upon physical criteria.

In conclusion, the ostracode fauna (see Table 1) is interpreted to indicate that the deposition of the "Bermont Formation" at Belle Glade, occurred in a low-energy environment, at a water depth of less than 23 meters under fully marine conditions in a subtropical or tropical region.

VI. ACKNOWLEDGMENTS

All samples were provided by Emily H. Vokes of Tulane University. She also offered much useful advice related to the preparation of this paper. Eileen Romeo Kontrovitz provided valuable assistance in locating certain old and rare bibliographic items. Laboratory materials used in this study were purchased with funds provided by a Rider College Grant-in-Aid. Richard H. Benson and Louis S. Kornicker of the U.S. National Museum, Robert V. Kesling of The University of Michigan and Alvin M. Phillips, Jr. of Louisiana State University kindly loaned type specimens for comparisons.

VII. SYSTEMATIC PALEONTOLOGY

All figured and type specimens are deposited at the U.S. National Museum (USNM). All illustrations for this paper are scanning electron micrographs.

Subclass OSTRACODA Latreille, 1806
Order PODOCOPIDA Müller, 1894
Suborder PODOCOPINA Sars, 1866
Superfamily BAIRDIACEA Sars, 1866
Family BAIRDIIDAE Sars, 1866
Genus BAIRDOPPILATA Coryell, Sample and Jennings, 1935

BAIRDOPPILATA (BAIRDOPPILATA) CUSHMANI (Tressler, 1949)
Plate 1, figure 5

Nesidea cushmani TRESSLER, 1949, p. 342, figs. 4-8.

Bairdoppilata carinata KORNICKER, 1961, p. 66, pl. 1, figs. 5a-e; text figs. 9A-J, 10B-C, E.

Bairdoppilata triangulata Edwards. BENSON and COLEMAN, 1963, p. 20-21, pl. 3, figs. 1-3; text fig. ? (not *Bairdoppilata triangulata* Edwards, 1944, p. 507, pl. 85, figs. 5-7).

TABLE 1. OSTRACODE FAUNAL LIST

	Locality		
	TU 201	TU 580	TU 733
Actinocythereis triangularis Morales	9*	1AF 6JV	1AF
Aurila sp. cf. *A. amygdala* (Stephenson)	2	4JV	—
"Aurila" floridana Benson and Coleman	23	2AF 11JV	4AF 7JV
"Aurila" bellegladensis, n. sp.	37	1AF 12JV	1AF 17JV
Bairdoppilata (Bairdoppilata) cushmani (Tressler)	3	—	1JV
Basslerites sp.	—	2 1JV	2
Cyprideis mexicana Sandberg	3	1JV	—
Cyprideis salebrosa van den Bold	7	9JV	8JV
Cytherella sp.	2	2JV	3JV
Cytherelloidea sp. aff. *C. leonensis* Howe	4	2JV	2JV
Cytheromorpha paracastanea (Swain)	10	10 2JV	1 2JV
Cytherura sp. cf. *C. sandbergi* Morales	1	1JV	1JV
Cytherura sp. A	3	1	1
Cytherura sp. B	2	2	—
Cytherura sp. C	1	—	—
Haplocytheridea bradyi (Stephenson)	8	—	—
Haplocytheridea setipunctata (Brady)	34	—	—
Hemicytherura vokesae, n. sp.	1	8 2JV	7 1JV
Hulingsina ashermani (Ulrich and Bassler)	5	1AF 9JV	3JV
Limnocythere sp.	7	3AF 13JV	—
Loxoconcha sp. cf. *L. matagordensis* Swain	3	1JV	1JV
Loxoconcha sp. cf. *L. sarasotana* Benson and Coleman	11	—	—
Loxocorniculum fischeri (Brady)	43	5AF 10JV	4AF 9JV
Loxocorniculum postdorsolatum (Puri)	6	1AF 3JV	2AF 5JV
Macrocyprina sp.	—	2AF	2JV
Megacythere edwardsi, n. sp.	12	1AF	1AF
Neocaudites sp. cf. *N. triplistriata* (Edwards)	1	—	1AF
Neonesidea sp. cf. *N. gerda* (Benson and Coleman)	1	—	—
Orionina bradyi van den Bold	16	3AF 3JV	2AF
Paracypris sablensis Benson and Coleman	6	2JV	—
Paracytheridea tschoppi van den Bold	3	1JV	1JV
Paracytheridea sp. cf. *P. vandenboldi* Puri	4	1JV	—
Paradoxostoma sp.	1AF	1AF	1JV
Paranesidea sp. cf. *P. bradyi* (van den Bold)	3	?3JV	—

Pellucistoma sp. aff. *P. atkinsi* Hall	1	1 2JV	3 9JV
Physocypria sp. cf. *P. pustulosa* Sharpe	5	2 1JV	1JV
Proteoconcha multipunctata (Edwards)	6	2JV	—
Protocytheretta pumicosa (Brady)	5	1AF 3JV	—
Puriana rugipunctata (Ulrich and Bassler)	14	1JV	2AF 2JV
Radimella confragosa? (Edwards)	25	—	—
Xestoleberis rigbyi Morales	10	1AF 1JV	2AF 6JV

* valve count, adults
AF = fragments, adults
JV = valve count, juveniles

Bairdoppilata (Bairdoppilata) cushmani (Tressler). MADDOCKS, 1969, p. 68-71, figs. 34, 35h-m.

DIMENSIONS: Left valve, length 1.00 mm, height .68 mm.

MATERIAL: Four valves.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of about 0.9 to 72.9 meters; marine; subtropical and tropical.

Genus PARANESIDEA Maddocks, 1969
PARANESIDEA sp. cf. P. BRADYI
(van den Bold, 1957)
Plate 1, figure 6

Bairdia foveolata BRADY, 1868, p. 56, pl. 7, figs. 4-6. BRADY, 1880, p. 55, pl. 8, figs. 1a-f, 2a-f (not *Bairdia foveolata* Bosquet, 1852, p. 21, pl. 1, figs. 5a-d).

cf. *Bairdia bradyi* VAN DEN BOLD, 1957, p. 236, pl. 1, fig. 5. PURI, 1960, p. 130-131. VAN DEN BOLD, 1966, p. 45, pl. 1, figs. 5a-c. MORALES, 1966, p. 23, pl. 1, figs. 4a-d. SWAIN, 1967, p. 36, pl. 7, fig. 4.

Bairdia sp. cf. *B. bradyi* van den Bold. BENSON and COLEMAN, 1963, p. 18-19, pl. 2, figs. 1-3, text fig. 7.

DIMENSIONS: Carapace, length .85 mm; height .54 mm; width .45 mm.

MATERIAL: A damaged carapace, four valves.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths from near the shoreline to 2103 meters; marine; subtropical and tropical.

Genus NEONESIDEA Maddocks, 1969
NEONESIDEA sp. cf. N. GERDA
(Benson and Coleman, 1963)
Plate 1, figure 8

cf. *Bairdia gerda* BENSON and COLEMAN, 1963, p. 19-20, pl. 1, figs. 14-16; text fig. 8.

Bairdia cf. *B. crosskeyana* Brady. BENDA and PURI, 1962, p. 324, pl. 5, figs. 12, 13 (not *Bairdia crosskeiana* Brady, 1866, p. 366, pl. 57, fig. 10).

Neonesidea gerda (Benson and Coleman). MADDOCKS, 1969, p. 24-26, figs. 7a-k.

MATERIAL: A single damaged valve.

REMARKS: The shape and muscle scars of the single valve appear to be identical to *N. gerda* (Benson and Coleman).

ENVIRONMENT: Previously reported from modern sediments deposited at water depths from near the shoreline to 15.2 meters; marine; subtropical and tropical.

Family MACROCYPRIDIDAE Müller, 1912
Genus MACROCYPRINA Triebel, 1960
MACROCYPRINA sp.
Plate 1, figure 7

DIMENSIONS: Juvenile, left valve, length .60 mm, height .28 mm.

MATERIAL: Two juvenile valves and two fragments of adult valves.

REMARKS: The limited nature of the material precludes identification at the species level. The juveniles were recovered from the sample taken at locality TU 733; the fragments are from TU 580.

Superfamily CYPRIDACEA Baird, 1845
Family PARACYPRIDIDAE Sars, 1925
Genus PARACYPRIS Sars, 1866
PARACYPRIS SABLENSIS
Benson and Coleman, 1963
Plate 1, figure 4

Paracypris? sablensis BENSON and COLEMAN, 1963, p. 16-17, pl. 1, figs. 11-13; text fig. 5.

DIMENSIONS: Left valves, length .80-.83 mm; height .39-.40 mm.

MATERIAL: Eight valves.

REMARKS: The muscle scars could not be seen on any specimen, but all other characters were identical to those of the lectotype (USNM 113181).

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 5.8 to 29.0 meters; marine; subtropical and tropical.

Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEINAE Sars, 1925
Genus CYPRIDEIS Jones, 1857
CYPRIDEIS SALEBROSA van den Bold, 1963
Plate 1, figure 9

Cyprideis salebrosa VAN DEN BOLD, 1963b, p. 377-378, pl. 7, figs. 9a-d; pl. 11, figs. 1a-c. SANDBERG, 1964b, p. 144-152, pl. 8, figs. 10-25; pl. 9, figs. 1-12; pl. 14, figs. 1-3; pl. 17, figs. 3a-f; pl. 18, fig. 10; pl. 20, figs. 5-10; pl. 22, figs. 5, 8 (with synonymy). VAN DEN BOLD, 1971, p. 452, 454. VAN DEN BOLD, 1972b, p. 486. KEYSER, 1975, p. 490, 493, text fig. 3. KONTROVITZ, 1976, p. 93, pl. 2, fig. 1.

DIMENSIONS: Right valve, length 1.20 mm; height .65 mm,

MATERIAL: Twnety-four valves.

REMARKS: The specimens are larger than those reported by van den Bold (1963b), but are similar in size to the range presented by Sandberg (1964b).

ENVIRONMENT: Previously reported from modern sediments deposited in estuaries, mangrove swamps and on the continental shelf of the Gulf of Mexico; water depths from near shore to more than 18.3 meters; brackish and marine; subtropical.

CYPRIDEIS MEXICANA Sandberg, 1964
Plate 1, figure 1

Cyprideis mexicana SANDBERG, 1964b, p. 125, pl. 11, figs. 11-14; pl. 12, figs. 1-5; pl. 17, fig. 1; pl. 20, figs. 1, 2; pl. 22, figs. 2, 9a,b. MORALES, 1966, p. 32, pl. 2, figs. 1a,b.

DIMENSIONS: Carapace, length 1.05 mm; height .56 mm; width .41 mm.

MATERIAL: One carapace, two valves.

REMARKS: This species is similar to *Anomocytheridea locketti* Stephenson, 1938, but lacks the "thickened flange of clear shell material" at the posteroventral margin of the right valve.

ENVIRONMENT: Previously reported from modern sediments deposited in shallow lagoons and from depths as great as 6.1 meters; brackish to marine; tropical.

Genus HAPLOCYTHERIDEA Stephenson, 1936
HAPLOCYTHERIDEA BRADYI (Stephenson, 1938)
Plate 1, figure 2

Cytheridea (Haplocytheridea) bradyi STEPHENSON, 1938, p. 129-132, pl. 23, fig. 22; pl. 24, figs. 5, 6; text fig. 10.

Haplocytheridea bradyi (Stephenson). SWAIN, 1955, p. 618, pl. 59, figs. 12a,b. PURI, 1960, p. 110, pl. 2, figs. 3, 4; pl. 6, fig. 19; text figs. 4, 5. SANDBERG, 1964a, p. 362-363, pl. 2, figs. 7-16. HALL, 1965, p. 41, pl. 11, figs. 1-11. HULINGS and PURI, 1965, p. 321, fig. 12. HULINGS, 1966, p. 50, fig. 6f. HULINGS, 1967, p. 642, fig. 3p. GROSSMAN, 1967, p. 64a, pl. 11, fig. 2; pl. 17, figs. 15, 16, 18. SWAIN, 1968, p. D8, pl. 1, figs. 7a,b, 8a,b; pl. 2, fig. 8. KRUTAK, 1971, p. 16, pl. 2, figs. 5a,b. VALENTINE, 1971, p. D6, pl. 2, figs. 42, 46. SWAIN, 1974, p. 13, pl. 1, figs. 9, 10, 13; pl. 8, figs. 10a,b. KONTROVITZ, 1976, p. 93, pl. 2, fig. 3.

Haplocytheridea bradyi Swain *(sic).* BYRNE, LEROY, and RILEY, 1959, p. 240, pl. 4, fig. 10; pl. 5, fig. 11.

Cytheridea (Haplocytheridea) wadei STEPHENSON, 1941, p. 428-429, text figs. 3, 4, 14-18.

Haplocytheridea wadei (Stephenson). PURI, 1953b, p. 231, pl. 3, figs. 5, 6; text fig. 3g.

Cytheridea (Haplocytheridea) proboscidiala EDWARDS, 1944, p. 508-509, pl. 85, figs. 8-11.

Haplocytheridea proboscidiala (Edwards). BENSON and COLEMAN, 1963, p. 28-29, pl. 3, figs. 4-9; text fig. 15.

"Haplocytheridea" bradyi (Stephenson). HAZEL, 1975, p. 477, 479.

DIMENSIONS: Right valves, length .73-.75 mm; height .43-.45 mm.

MATERIAL: Eight valves.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 0.9 to 62.2 meters; brackish and marine; mild temperate, subtropical and tropical. Also reported from the Cape Hatteras area, North Carolina (Hazel, 1975).

HAPLOCYTHERIDEA SETIPUNCTATA (Brady, 1869)
Plate 1, figure 2

Cytheridea setipunctata BRADY, 1869, p. 124, pl. 14, figs. 15, 16.

Haplocytheridea setipunctata (Brady). SANDBERG, 1964a, p. 361-362, pl. 1, figs. 10-14; pl. 2, figs. 1-4 (with synonymy). HULINGS and PURI, 1965, p. 329, fig. 14. SANDBERG, 1965, p. 508, pl. 3, fig. 12. HULINGS, 1967, p. 643, fig. 3q. GROSSMAN, 1967, p. 64a, pl. 11, figs. 4, 7; pl. 16, figs. 13-18. SWAIN, 1968, p. D7-8, pl. 1, figs. 5a-c; pl. 7, figs. 1a,b. VALENTINE, 1971, p. D6, pl. 2, figs. 48, 49. SWAIN, 1974, p. 12-13, pl. 9, fig. 16. VAN DEN BOLD, 1971, p. 452, 454.

DIMENSIONS: Left valve, ? female, length 1.13 mm; height .74 mm.

MATERIAL: Thirty-two valves; one juvenile carapace.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 0.6 to 21.3 meters; brackish and marine; subtropical and tropical.

Subfamily NEOCYTHERIDEINAE Puri 1957

Genus HULINGSINA Puri, 1957

HULINGSINA ASHERMANI (Ulrich and Bassler, 1904)

Plate 2, figure 8

Cytherideis ashermani ULRICH and BASSLER, 1904, p. 126, pl. 37, figs. 10-16.

Hulingsina ashermani (Ulrich and Bassler). PURI, 1958a, p. 173, table 2. POOSER, 1965, p. 45, pl. 6, fig. 5; pl. 8, figs. 1-3. HULINGS and PURI, 1965, p. 323, fig. 12a. MCLEAN, 1966, p. 74, pl. 23, fig. 4. GROSSMAN, 1967, p. 68, pl. 14, fig. 2; pl. 20, figs. 13-14 (with synonymy). KONTROVITZ, 1976, p. 62, pl. 2, fig. 5.

Pontocythere ashermani (Ulrich and Bassler). HULINGS, 1966, p. 51, figs. 2a-g, 6n. HULINGS, 1967, p. 645, fig. 5e. SWAIN, 1968, p. D10, pl. 2, figs. 1a-d; pl. 6, fig. 4; text fig. 8. SWAIN, 1974, pl. 1, figs. 21, 24; pl. 2, figs. 1-3; pl. 9, figs. 12a,b.

DIMENSIONS: Left valve, length .73 mm; height .38 mm.

MATERIAL: Eighteen valves.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 1.5 to 91.4 meters; brackish to marine; subtropical and tropical.

Family CYTHERURIDAE Müller, 1894

Genus CYTHERURA Sars, 1866

CYTHERURA sp. cf. C. SANDBERGI Morales, 1966

Plate 2, figure 1

cf. *Cytherura sandbergi* MORALES, 1966, p. 50, 52, pl. 4, figs. 6a-d (with synonymy). KRUTAK, 1971, p. 20-21, pl. 2, figs. 3a,b. KONTROVITZ, 1976, p. 63, pl. 3, fig. 1.

DIMENSIONS: Right valve, length .60 mm; height .35 mm.

MATERIAL: Three valves.

REMARKS: The valves are larger than the specimens examined by Morales (1966); other characters are similar.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 3.1 to 54.9 meters; brackish to marine; subtropical and tropical.

CYTHERURA sp. A

Plate 2, figure 5

Cytherura sp. A KONTROVITZ, 1976, p. 63, pl. 3, fig. 7.

DIMENSIONS: Left valve, ? juvenile, length .41 mm; height .24 mm.

MATERIAL: Five valves.

REMARKS: The five valves reported here and the three previously described are insufficient to name the species.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 33.0 to 56.7 meters; marine; subtropical.

CYTHERURA sp. B

Plate 2, figure 3

DESCRIPTION: Right valve, moderately calcified, small. Lateral view, subrectangular. Cardinal angles rounded. Dorsal margin nearly striaght with slight concavity at mid-length, ventral margin parallel with slight concavity in front of mid-length. Anterior margin, broadly rounded; posterior, triangular with apex equal to the caudal process just above mid-height.

Surface: About 12 distinct longitudinal ridges joined to a posterior sub-vertical rib; three join anterior rim. The posteroventral rib is high, alalike. Eyespots, weak.

Internal features: Marginal area, wide at anterior, narrow elsewhere. Inner margin may be serrate (possibly eroded). Radial pore canals at anterior, few, sinuous or simply curved, a few false; at posterior, few, simple. Hinge normal for genus. Muscle scars not seen.

DIMENSIONS: Right valve, length .58 mm; height .31 mm.

MATERIAL: Four valves.

REMARKS: This species differs from *Cytherura wardensis* Howe and Brown,

1935, and *Cytherura pseudostriata* Hulings, 1966, in its shape and in lacking a retictulate surface. Valentine (1971) reported specimens identified as *C. pseudostriata* Hulings that are similar in shape, but those have a reticulate surface in contrast to this species.

CYTHERURA sp. C
Plate 2, figure 7

? *Cytherura* sp. aff. *C. forulata* Edwards. MORALES, 1966, p. 46, 48, pl. 4, figs. 7a,b (not *Cytherura forulata* Edwards, 1944, p. 526, pl. 88. figs. 17-20).

DIMENSIONS: Left valve, length .59 mm; height .33 mm.

MATERIAL: One valve.

REMARKS: This species differs from *Cytherura forulata* Edwards by not having an arched dorsal margin; it is slightly concave at mid-length.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of less than 1.8 meters; marine; tropical.

Genus HEMICYTHERURA Elofson, 1941
HEMICYTHERURA VOKESAE
Kontrovitz, n. sp.
Plate 2, figures 2, 4

DIAGNOSIS: Distinguished by its elongate rectangular shape, prominent horizontal ridges and distinct cross-ridges.

DESCRIPTION: Moderately calcified, small, rectangular in lateral view. Females, dorsal margin nearly straight; ventral margin slightly convex and subparallel. Males, dorsal and ventral margins nearly straight and parallel. Both sexes have anterior margin evenly rounded; posterior evenly rounded below mid-length, a slightly upturned caudal process above.

Surface is reticulate with high, delicate horizontal ridges. The dorsal and ventral marginal ridges are most prominent being fluted on well preserved specimens. Rib just above ventral rib bifurcates then unites again reaching the low anterior rim. All horizontal ribs connect to sinuous vertical rib just in front of posterior.

Sexual dimorphism: As above, males also lower.

Internal view: Valves deep. Hinge, right valve, selvage is extended into high blade-like elements that reach toward center just beyond cardinal angles; above hinge elements there is a distinct flange groove. Left valve, a long blade-like medial element expanded at each end; fits between terminal elements of right valve.

Inner lamella is wide at anterior, narrow elsewhere. Inner margin, slightly serrate at anterior. No vestibules. Radial pore canals, few and curved. Muscle scars not seen.

HOLOTYPE: Left valve, female, figured, USNM 236001; length .47 mm; height .26 mm.

PARATYPES: Right valve, female, figured, USNM 236002; length .44 mm, height .24 mm. Left valve, female, USNM 236003; length .45 mm, height .26 mm. Right valve, male, USNM 236004; length .46 mm, height .23 mm. Left valve, male, USNM 236005; length .45 mm, height .24 mm.

TYPE LOCALITY: Tulane University Department of Geology Locality 580 (see section VIII of this study).

DIMENSIONS: Females, right valves, length .44-.48 mm; height .24-.26 mm. Males, right valves, length .45-.46 mm; height .21-.24 mm.

MATERIAL: Nineteen valves.

REMARKS: This specimen is similar to *Hemicytherura sablensis* Benson and Coleman, 1963, in outline, but differs from the latter by having distinct cross-ribs between the horizontal ribs. An examination of the lectotype (USNM 113199) also revealed that *H. sablensis* has straight horizontal ribs; horizontal ribs are sinuous on *H. vokesae,* n. sp. The species is named in honor of Dr. Emily H. Vokes of Tulane University for her contributions to paleontology.

Genus PARACYTHERIDEA Müller, 1894
PARACYTHERIDEA sp.
cf. P. VANDENBOLDI Puri, 1953
Plate 3, figure 1

Cytheropteron nodosum ULRICH and BASSLER, 1904, p. 129-130, pl, 38, figs. 37-40. (Not *Cytheropteron nodosum* Brady, 1868, p. 448, pl. 34, figs. 31-34.)

Paracytheridea nodosa (Ulrich and Bassler). HOWE *et al.,* 1935, p. 37, pl. 3, fig. 7. VAN DEN BOLD, 1946, p. 86, pl. 16, fig. 7. SWAIN, 1951, p. 51, pl. 3, figs. 19-22.

cf *Paracytheridea vandenboldi* PURI, 1953c, p. 751. PURI, 1953b, p. 238, 240, pl. 3, fig. 7; text figs. 5a,b. MALKIN, 1953, p. 780, pl. 79, fig. 5. SWAIN, 1955, p. 625, pl. 62, figs. 2a, b. MCLEAN, 1957, p. 75-76, pl. 8, figs. 4a, 4b. HALL, 1965, p. 49, pl. 18, figs. 22-30. MCLEAN, 1966, p. 61-62.

Paracytheridea cf. *P. vandenboldi* Puri. SWAIN, 1968, p. D11, pl. 2, figs. 4a,b.

DIMENSIONS: Left valve, length .81 mm, height .42 mm.

MATERIAL: Five valves.

REMARKS: Although these specimens are larger than those reported by Ulrich and Bassler (length .68 mm; height .30 mm) they are similar in all other characteristics.

ENVIRONMENT: Previously reported from modern sediments deposited at water

depths of about 1.7 meters; brackish; subtropical (Swain, 1955).

PARACYTHERIDEA TSCHOPPI
van den Bold, 1946
Plate 2, figure 6

Paracytheridea tschoppi VAN DEN BOLD, 1946, p. 85, pl. 16, figs. 6, 7, KINGMA, 1948, p. 74, pl. 7, fig. 12. KEIJ, 1954, p. 220, pl. 4, fig. 4. VAN DEN BOLD, 1957, p. 245, pl. 4, fig. 7. BENSON AND COLEMAN, 1963, p. 33-34, pl. 6, figs. 7, 9, 10; text figs. 20a,b. VAN DEN BOLD, 1967a, p. 313. VAN DEN BOLD, 1968, p. 76, pl. 4, figs. 8a-d. VAN DEN BOLD, 1972a, p. 434.

Paracytheridea vanwessemi VAN DEN BOLD, 1946, p. 86, pl. 16, fig. 13.

Paracytheridea sp. 1, DROOGER and KAASSHIETER, 1958, p. 91.

DIMENSIONS: Right valve, length .63 mm; height .36 mm.

MATERIAL: Five valves.

REMARKS: These specimens are larger than the type individuals, but are similar in other characters.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of about 6.1 to 39.6 meters; marine; subtropical and tropical.

Family HEMICYTHERIDAE Puri, 1953
Subfamily HEMICYTHERINAE Puri, 1953
Genus AURILA Pokorný, 1955
AURILA sp. cf. A. AMYGDALA
(Stephenson, 1944)
Plate 2, figure 9

cf. *Hemicythere amygdala* STEPHENSON, 1944, p. 158, pl. 28, figs. 8, 9. PURI, 1953a, p. 176, pl. 1, fig. 3. PURI, 1953b, p. 266, pl. 11, fig. 14. PURI, 1960, p. 129, text figs. 31, 32.

Aurila amygdala (Stephenson). BENSON and COLEMAN, 1963, p. 36, pl. 8, figs. 6, 8, 9; text figs. 22a,b. BUTLER, 1963, p. 73, pl. 2, fig. 16; pl. 6, fig. C. VAN DEN BOLD, 1965, p. 394-395, pl. 5, fig. 10. MORALES, 1966, p. 56, pl. 5, figs. 6a-d. HULINGS, 1967, p. 647. VAN DEN BOLD, 1967b, p. 394-395, pl. 5, fig. 16. VAN DEN BOLD, 1972a, p. 427-428. VAN DEN BOLD, 1972b, p. 486, POAG, 1974, p. 59, pl. 6, fig. 5; text fig. 2.

DIMENSIONS: Carapace, length .56 mm; height .36 mm; width .26 mm.

MATERIAL: Two adult carapaces and four juvenile valves.

REMARKS: The few specimens do not allow exact identification, but the observed characters indicate that this is probably the species Stephenson (1944, p. 158) described.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 1.5 to 7.6 meters; brackish to marine (29-39 o/oo); subtropical and tropical.

"AURILA" FLORIDANA
Benson and Coleman, 1963
Plate 3, figure 2

Aurila conradi (Howe and McGuirt) *floridana* BENSON and COLEMAN, 1963, p. 35-36, pl. 8, figs. 10-12; text fig. 21. HALL, 1965, p. 32, pl. 6, figs. 20-22, 24, 29.

Aurila floridana Benson and Coleman. MORALES, 1966, p. 56-57, pl. 5, figs. 5a-d (with synonymy). VALENTINE, 1971, p. D4, pl. 1, figs. 43, 47. HAZEL, 1971b, p. 370. KONTROVITZ, 1976, p. 69, pl. 4, fig. 6.

Aurila? floridana Benson and Coleman. HAZEL, 1971b, p. 370.

Radimella floridana (Benson and Coleman). HAZEL, 1971a, p. 6.

Radimella? floridana floridana (Benson and Coleman). HAZEL, 1975, p. 478.

DIMENSIONS: Right valves, length .65-.68 mm; height .43-.45 mm.

MATERIAL: Two carapaces (juvenile), 43 adult valves.

REMARKS: The adult specimens examined for this study are larger than those of Benson and Coleman (1963) and Morales (1966), but are identical in other characters. A new genus is being proposed by J. E. Hazel (*Smithsonian Contributions to Paleobiology*, in press) for *A conradi, A. floridana* and related North American forms.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 1.5 to 62.2 meters; brackish to marine (27-40 o/oo); mild temperate, subtropical and tropical. Also reported by Hazel (1975) from the Cape Hatteras area, North Carolina.

"AURILA" BELLEGLADENSIS
Kontrovitz, n. sp.
Plate 3, figures 4, 5

DIAGNOSIS: Distinguished by the highly arched dorsum, polished ridges, blunt caudal process of the right valve and small tooth in the bottom of the posterior socket of the left valve hinge.

DESCRIPTION: Almond shaped, moderately calcified, medium size. In lateral view, ovate, pronounced overlap by left valve only at dorsum; dorsal margin is broadly rounded. In left view,

anterior cardinal angle is broadly rounded; posterior cardinal angle more sharply rounded. Dorsal margin slopes markedly to rear. Greatest height is at anterior cardinal angle, greatest length below middle (length/height ratio, left valves, 1.4). Anterior margin, rimmed and broadly curved below mid-height, more oblique above. Posterior margin has concavity above mid-height, caudal process below. Ventral margin, gently convex with slight sinuosity near mid-length. Sexual dimorphism not apparent.

Dorsal view: Ovate, greatest width at mid-length, slopes evenly to anterior and posterior. Left valve slightly larger.

End view, anterior: Ovate, greatest width below mid-height, venter slightly flattened.

Surface: Anterior is reticulate with about six coarse reticulations parallel to anterior rim. Smaller reticulations at mid-length; at posterior, shape of depressions becomes irregular. Area between depressions (the ridges) are flattened and polished. Some specimens have smooth subcentral area and weak posterodorsal ridge. A low ventrolateral ridge has about 10-11 pits giving a weakly fluted appearance. Eyespot small but distinct and on an arcuate ridge that is parallel to nearest margin.

Internal features: Valves deep; caudal process blunt in right valve. Hinge, right valve, anterior element is an oval tooth on a ramp, followed by a rounded socket, then a curved medial groove, a posterior tooth that is crescent-shaped and slightly enlarged at each end. Left valve, a rounded anterior socket followed by a large oval tooth that is the terminus of the long narrow crenulate medial bar; posterior socket is oval, elongate and has a small tooth at its bottom edge.

Inner lamella is narrow; anterior vestible is very narrow; posterior vestibule small and only at caudal process. Radial pore canals, numerous and closely spaced at lower anterior margin, more widely spaced and slightly sinuous at upper anterior.

Selvage, right valve, low but distinct at anterior, higher and sharper at the ventral margin where it is flexed inward just in front of mid-length; at posterior selvage is parallel to margin and forms a groove like depression with flange (a flange groove). Selvage continues onto caudal process. Selvage of left valve is low but distinct, fits into groove of right valve, is removed from outer margin on caudal process.

Muscle scars: Central scars, a group of three with the upper one circular; middle is horizontally elongate and divided; lower scar is elongate, divided and sloping toward anteroventral margin. Frontal scar is divided into three areas, slopes forward.

HOLOTYPE: Left valve, figured, USNM 235996; length .60 mm, height .39 mm.

PARATYPES: Right valve, figured, USNM 235997; length .55 mm, height .29 mm. Left valve, USNM 255998; length .60 mm, height .39 mm. Right valve, USNM 255999; length .59 mm, height .33 mm. Carapace, ? juvenile, USNM 236000; length .53 mm, height .35 mm, width .29 mm.

TYPE LOCALITY: Tulane University Department of Geology Locality 201 (see section VIII of this study).

DIMENSIONS: Carapaces, ? juveniles, length .53-.56 mm; height .35-.38 mm; width .29-.30 mm; left valves length .55-.60 mm; height .38-.41 mm. L/H ratio of left valves = 1.4.

MATERIAL: Eight carapaces, 52 valves.

REMARKS: This species is similar to *Aurila conradi* (Howe and McGuirt) *californica* Benson and Kaesler, 1963, but differs by having a blunt caudal process in the right valve, not a pointed one. This species also has a less distinct posteroventral ridge and larger eyespots. The course of the selvage is different in the ventral portion of the valves and this species lacks marginal denticles below the caudal process.

The species differs from *Aurila floridana* Benson and Coleman, 1963, by lacking marginal denticles, by the presence of a small tooth in the posterior socket of the left valve hinge and in the more subdued ridges of the surface ornamentation. This species is probably a member of a new genus that will be described by Joseph E. Hazel (Hazel, 1977, personal communication).

The species is named for its occurrence near the town of Belle Glade, Florida.

Genus RADIMELLA Pokorný, 1969

RADIMELLA CONFRAGOSA? (Edwards, 1944)

Plate 3, figure 3

? *Hemicythere confragosa* EDWARDS, 1944, p. 518, pl. 86, figs. 23-26.

? *Radimella confragosa* (Edwards). VAN DEN BOLD, 1975, p. 697, pl. 1, figs. 1-4, 16, 17; text figs. 3a, b (with synonymy).

DIMENSIONS: Carapaces, length .56-.60 mm; height .34-.36 mm; width .36-.38 mm.

MATERIAL: Six carapaces, 13 valves.

REMARKS: This species differs slightly from the Holotype of *Radimella confragosa* (Edwards) by having a more evenly rounded anterior margin, somewhat heavier ornamentation and by having two posterior marginal spines above the caudal process. The posterior marginal spines are similar to those of *Radimella confragosa* form A of van den Bold (1975) but the shape and general ornamentation differ from that form. The details

of the shape and ornamentation serve to differentiate this species from the other forms described by van den Bold (1975) in his study of *Radimella* ex gr. *confragosa* (Edwards).

Genus ORIONINA Puri, 1953
ORIONINA BRADYI van den Bold, 1963
Plate 3, figure 6

Orionina bradyi VAN DEN BOLD, 1963a, p. 45, 47, pl. 3, figs. 7, 8, text fig. 6, figs. 5-7 (with synonymy). MORALES, 1966, p. 85, 87, pl. 8, figs. 2a-c. VALENTINE, 1971, p. D8. VAN DEN BOLD, 1974, p. 217. HAZEL, 1975, p. 477.

? *Orionina bermudae* (Brady). BENSON and COLEMAN, 1963, p, 45-46, pl. 8, fig. 7; text fig. 29 (not *Cythere bermudae* Brady, 1880, p. 90, pl. 21, figs. 2a-d).

DIMENSIONS: Carapaces, length .56-.61 mm; height .31-.35 mm; width .26-.30 mm.

MATERIAL: Three carapaces, 18 valves.

REMARKS: The marginal area, hinge and "pillar" structures are identical to those described by van den Bold (1963a). The ornamentation is variable and is similar on some specimens to that of *Orionina vaughni* (Ulrich and Bassler, 1904).

ENVIRONMENT: Previously reported from modern sediments deposited from shallow depths to about 792.5 meters; marine; subtropical and tropical.

Subfamily CAMPYLOCYTHERINAE Puri, 1960
Genus PROTEOCONCHA Plusquellec and Sandberg, 1969
PROTEOCONCHA MULTIPUNCTATA (Edwards, 1944)
Plate 3, figure 8

Acuticythereis multipunctata EDWARDS, 1944, p. 520, pl. 87, figs. 14-16.

Proteoconcha multipunctata (Edwards). PLUSQUELLEC and SANDBERG, 1969, p. 457-459, pl. 2, figs. 1-11; pl. 5, fig. 9; pl. 6, figs. 12, 13; pl. 8, fig. 5; pl. 9, figs. 6, 10, 12-16; text figs. 2h-i, 3d, 4, 12. HAZEL, 1971b, p. 370. VALENTINE, 1971, p. D8. HAZEL, 1975, p. 378.

DIMENSIONS: Right valve, ? female, length .65 mm; height .36 mm.

MATERIAL: One carapace, six valves.

ENVIRONMENT: A modern specimen from Florida Bay has been identified, tentatively, as a representative of this species (Plusquellec and Sandberg, 1969, p. 458). In addition, the species has been reported from the Cape Hatteras area, North Carolina (Hazel, 1975).

Subfamily THAEROCYTHERINAE Hazel, 1967
Genus PURIANA Coryell and Fields, in Puri, 1953
PURIANA RUGIPUNCTATA (Ulrich and Bassler, 1904)
Plate 3, figure 7

Cythere rugipunctata ULRICH and BASSLER, 1904, p. 118 pl. 38, figs. 16, 17.

Cythereis rugipunctata (Ulrich and Bassler). HOWE *et al.*, 1935, p. 23, pl. 1, figs. 18, 20-22; pl. 4, figs. 22, 23.

Favella rugipunctata (Ulrich and Bassler). EDWARDS, 1944, p. 524, pl. 88, figs. 5, 6. VAN DEN BOLD, 1950, p. 797, pl. 83, fig. 24.

Puriana rugipunctata (Ulrich and Bassler). PURI, 1953c, p. 571. VAN DEN BOLD, 1965, p. 399. HULINGS, 1966, p. 55, fig. 8i. HULINGS, 1967, p. 654-655, fig. 8. SWAIN, 1974, pl. 7, figs. 19, 20 (with synonymy). HAZEL, 1971b, p. 370, VALENTINE, 1971, p. D8, pl. 4, figs. 31, 36. HALEZ, 1975, p. 478. KONTROVITZ, 1976, p. 69, 70, pl. 4, fig. 5.

DIMENSIONS: Left valves, length .58-.60 mm; height .28-.32 mm.

MATERIAL: Five carapaces, nine valves.

REMARKS: The specimens reported here are smaller than those described by Ulrich and Bassler (left valve, length .71 mm, height .38 mm).

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 1.5 to 381 meters with the most common occurrences at depths of less than 76.2 meters; brackish and marine; mild temperate, subtropical and tropical.

Family LOXOCONCHIDAE Sars, 1925
Genus LOXOCONCHA Sars, 1866
LOXOCONCHA sp. cf. L. SARASOTANA Benson and Coleman, 1963
Plate 4, figure 2

cf. *Loxoconcha sarasotana* BENSON and COLEMAN, 1963, p. 37, pl. 7, figs. 7-10; text fig. 23a.

? *Loxoconcha* sp. aff. *L. sarasotana* Benson and Coleman. MORALES, 1966, p. 71-72, pl. 6, figs. 2a,b.

DIMENSIONS: ? Female, right valve, length .55 mm; height .35 mm; ? male, right valve, length .59 mm; height .33 mm.

MATERIAL: Eleven valves.

REMARKS: None of the specimens examined have the distinct posterior ridge described by Benson and Coleman (1963). A posterior ridge is weakly formed on several valves, but it is not equally developed on all specimens. In addition, the valves reported here are smaller than the type specimens.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 6.1 to 19.2 meters; marine; subtropical. Morales (1966) reported a similar form from shallow, brackish to marine waters in the tropics.

LOXOCONCHA sp. cf. L. MATAGORDENSIS
Swain, 1955
Plate 4, figure 1

cf. *Loxoconcha matagordensis* SWAIN, 1955, p. 629, pl. 63, figs. 9a, b; pl. 64, figs. 1a, b; text figs. 36b, 39: 7a,b. MORALES, 1966, p. 66, 69, pl. 6, figs. 4a,b (with synonymy). GROSSMAN, 1967, p. 74, pl. 15, fig. 3; pl. 18, figs. 7, 8, 11. VALENTINE, 1971, p. D6, pl. 4, figs. 38-39, 43-44. HAZEL, 1971b, p. 370. HAZEL, 1975, p. 477. KONTROVITZ, 1976, p. 72, pl. 5, fig. 1.

Loxoconcha metagordensis [sic] Swain. HALL, 1965, p. 50, pl. 19, figs. 15-18.

DIMENSIONS: Carapace, length .55 mm; height .30 mm; width .16 mm.

MATERIAL: One carapace, three juvenile valves.

REMARKS: The subsidiary ridges described by Swain (1955) as characteristic of this species are visible only with low angle lighting on the adult specimen.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 0.6 to 128.0 meters; brackish to marine; subtropical and tropical.

Genus LOXOCORNICULUM
Benson and Coleman, 1963
LOXOCORNICULUM POSTDORSOALATUM
(Puri, 1960)
Plate 4, figure 4

Loxoconcha anderseni Puri. PURI and HULINGS, 1957, fig. 11 (not *Loxoconcha anderseni* Puri, 1953b, p. 269, pl. 10, fig. 4; text fig. 10c).

Loxoconcha postdorsoalata PURI, 1960, p. 111, pl. 3, figs. 17, 18; text figs. 35, 37.

Loxocorniculum postdorsolatum (Puri). BENSON and COLEMAN, 1963, p. 39-40, pl. 7, figs. 1, 2; text fig. 25.

DIMENSIONS: Carapace, male, length .65 mm; height .38 mm; width .30 mm.

MATERIAL: One carapace, 15 valves.

ENVIRONMENTS: Previously reported from modern sediments deposited at water depths from the shore line to 19.2 meters; marine; subtropical and tropical.

LOXOCORNICULUM FISCHERI
(Brady, 1869)
Plate 4, figure 3

PLATE 1

Figure — Page

1. *Cyprideis mexicana* Sandberg, right valve
USNM 236016, X100 140
2. *Haplocytheridea bradyi* (Stephenson), right valve
USNM 236024, X100 140
3. *Haplocytheridea setipunctata* (Brady), left valve
USNM 236025, X60 140
4. *Paracypris sablensis* Benson and Coleman, left valve
USNM 236037, X60 139
5. *Bairdoppilata (Bairdoppilata) cushmani* (Tressler), right valve
USNM 236014, X60 137
6. *Paranesidea* sp. cf. *P. bradyi* (van den Bold), right valve,
USNM 236041, X100 139
7. *Macrocyprina* sp., left valve
USNM 236033, X60 139
8. *Neonesidea* sp. cf. *N. gerda* (Benson and Coleman), right valve, damaged
USNM 236035, X60 139
9. *Cyprideis salebrosa* van den Bold, right valve
USNM 236017, X60 140

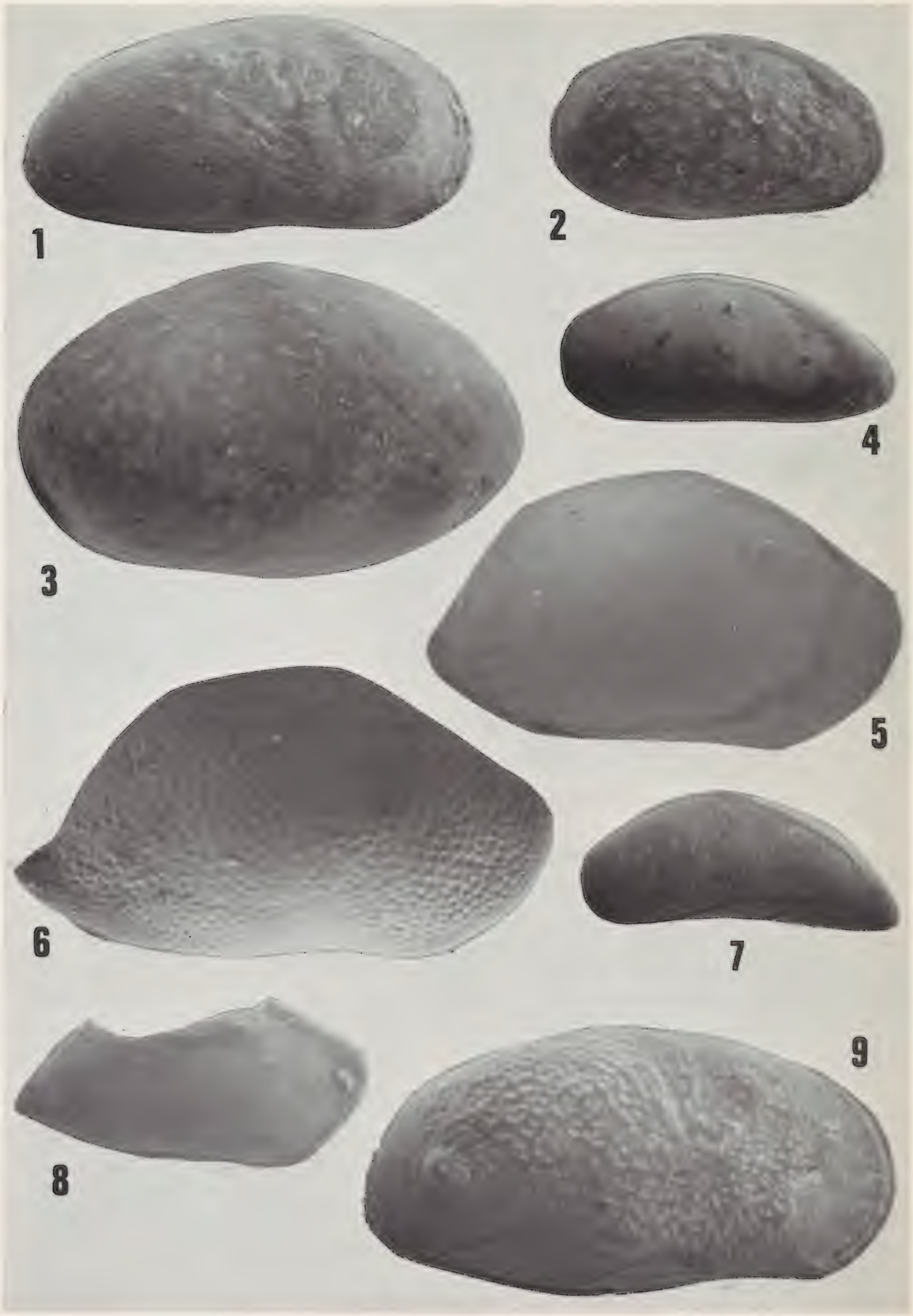

PLATE 1

Cythere fischeri BRADY, 1869, p. 152, 154, pl. 18, figs. 15, 16.
Loxoconcha fischeri (Brady). VAN DEN BOLD, 1963b, p. 393-394, pl. 8, figs. 8, 9 (with synonymy). VAN DEN BOLD, 1966, p. 51, pl. 3, fig. 7. HOWE and VAN DEN BOLD, 1975, p. 307, pl. 2, fig. 17.
Loxocorniculum fischeri (Brady). BENSON and COLEMAN, 1963, p. 39, pl. 7, figs. 3, 4; text fig. 24.

DIMENSIONS: Left valves, female, length .50 mm; height .33 mm; male, length .58 mm; height .34 mm.

MATERIAL: Four carapaces, 63 valves.

ENVIRONMENT: Previously reported from modern sediments deposited in waters ranging from shallow depths to about 259.1 meters; marine; tropical.

Genus CYTHEROMORPHA Sars, 1925
CYTHEROMORPHA PARACASTANEA
(Swain, 1955)
Plate 4, figure 9

Leptocythere paracastanea SWAIN, 1955, p. 640, pl. 62, fig. 7; ? pl. 63, figs. 1a-c; ? text figs. 39: 5a, b. CURTIS, 1960, p. 478, pl. 2 (top), fig. 13. ENGEL and SWAIN, 1967, p. 413, pl. 2, fig. 20. SWAIN, 1974, p. 26, pl. 4, figs. 5-8, pl. 9, figs. 6a,b. KONTROVITZ, 1976, p. 74, 76, pl. 5, fig. 9. *Not* DARBY, 1965, p. 20, pl. 3, figs. 1-10; pl. 4, figs. 1-9.
Cytheromorpha paracastanea (Swain). MORALES, 1966, p. 66, pl. 6, fig. 20.

DIMENSIONS: Left valve, length .51 mm, height .26 mm.

MATERIAL: Eight carapaces and 15 valves.

REMARKS: The medial sulcus is less distinct than on the type specimen (Swain, 1955). All other characters are similar. Darby (1965) reported a form as being this species but his specimens differ by having more arched dorsal margins and by having the greatest length at or above mid-height. The hingement of this species is that of *Cytheromorpha* (see Van Morkhoven, 1963, p. 396-398).

ENVIRONMENT: Previously reported from modern sediments deposited at water depths of 1.5 to 152.4 meters; brackish to marine; subtropical and tropical.

Family PARADOXOSTOMATIDAE
Brady and Norman, 1889
Subfamily PARADOXOSTOMATINAE
Brady and Norman, 1889
Genus PARADOXOSTOMA Fischer, 1855
PARADOXOSTOMA sp.
Plate 2, figure 10

DIMENSIONS: Damaged valve, length .71 mm.

PLATE 2

Figures Page

1. *Cytherura* sp. cf. *C. sandbergi* Morales, right valve
USNM 236020, X110 141
2. *Hemicytherura vokesae* Kontrovitz, n. sp., Holotype, left valve
USNM 236001, X100 142
3. *Cytherura* sp. B, right valve
USNM 236022, X100 141
4. *Hemicytherura vokesae* Kontrovitz, n. sp., Paratype, right valve
USNM 236002, X100 142
5. *Cytherura* sp. A, left valve
USNM 236021, X100 141
6. *Paracytheridea tschoppi* van den Bold, left valve
USNM 236038, X100 143
7. *Cytherura* sp. C, left valve
USNM 236023, X100 142
8. *Hulingsina ashermani* (Ulrich and Bassler), left valve
USNM 236026, X100 141
9. *Aurila* sp. cf. *A. amygdala* (Stephenson), left valve
USNM 236012, X100 143
10. *Paradoxostoma* sp., left valve, damaged
USNM 236040, X60 148

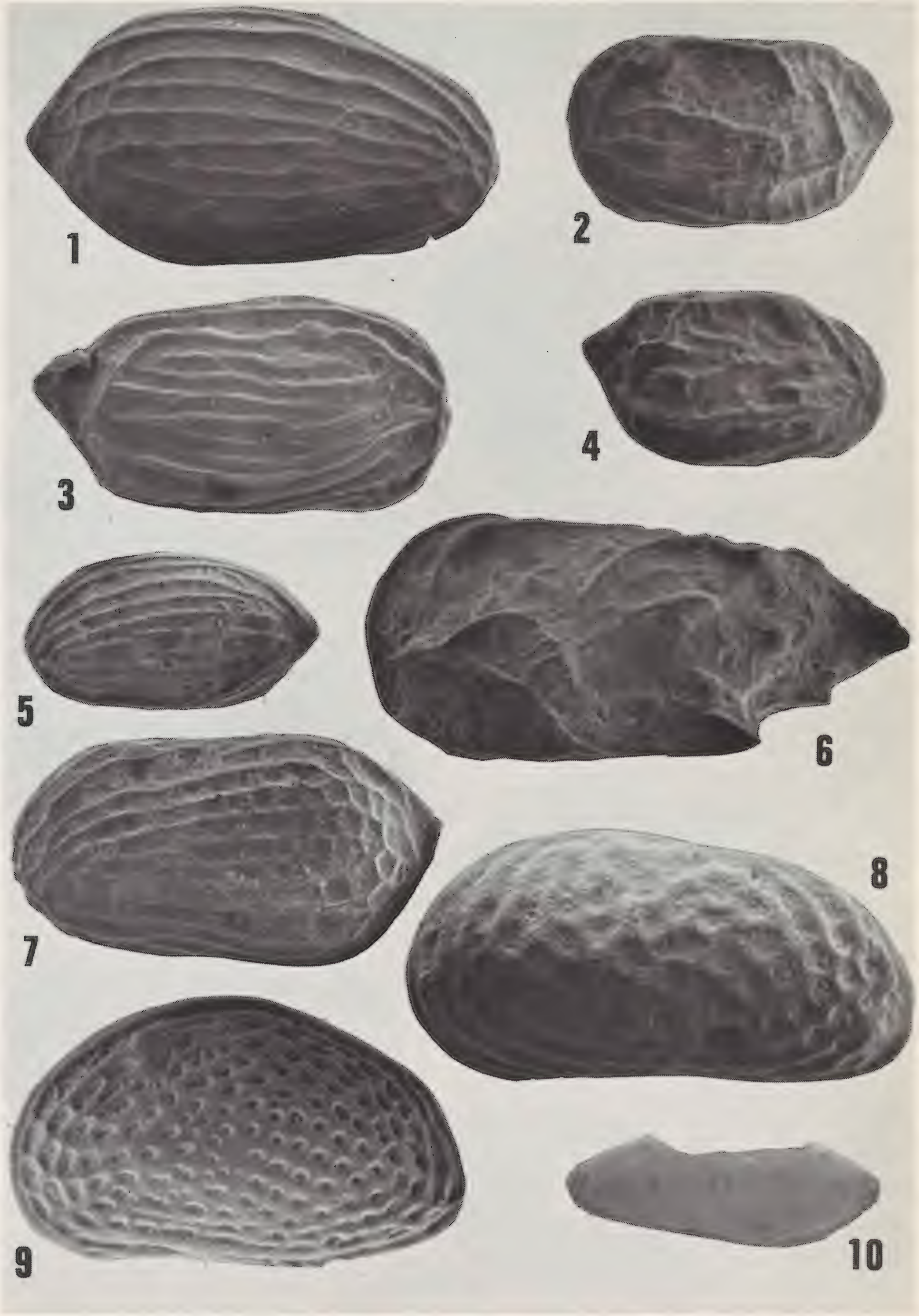

PLATE 2

MATERIAL: Two damaged right valves and one juvenile valve.

REMARKS: The material is insufficient for identification at the species level. The damaged adults were recovered from the sample taken at locality TU 580; the juvenile is from TU 733.

Genus MEGACYTHERE Puri, 1960

REMARKS: See Hall's (1965) discussion of the validity of this genus.

MEGACYTHERE EDWARDSI Kontrovitz, n. sp.

Plate 4, figures 5, 6

DIAGNOSIS: Distinguished by the straight dorsum and sinuous ventrum that converge anteriorly, the acutely rounded caudal process in the right valve and the ornamentation of numerous sinuous longitudinal ridges and cross-ridges that give a reticulate appearance.

DESCRIPTION: Moderately calcified, medium size. Trapezoidal in lateral view. Dorsal margin is nearly straight; ventral margin is sinuous and converging anteriorly. Anterior margin broadly rounded; posterior margin, broadly rounded below mid-height, an acutely rounded caridal process at mid-height; above, straight and sloping up to posterior cardinal angle. No dimorphic features.

Surface: Reticulate, with about nine to 12 sinuous horizontal ridges; cross-ridges are distinct but less pronounced. Ornamentation becomes weak near anterior and posterior margins.

Internal features: Hinge, right valve, anterior element is elongate and curved with convex side toward center of valve, enlarged at anterior, A socket lies above anterior element. Medial element, an indistinct groove. Posterior element is an enlarged extension of selvage from posterior. Left valve, a long medial bar is enlarged anteriorly into a high thin tooth; bar is also slightly enlarged at posterior.

Marginal area, widest at anterior, narrows slightly at posteroventral and ventral regions. Anterior vestibule is distinct. Radial pore canals, widely spaced, often bifurcating with funnel-shaped openings at anterior; few false.

Muscle scars not observed.

HOLOTYPE: Left valve, figured, USNM 236006; length .60 mm, height .30 mm.

PARATYPES: Right valve, figured, USNM 236007; length .55 mm, height .29 mm. Left valve, USNM 236008; length .60 mm, height .30 mm. Right valve, USNM 236009; length .59 mm, height .33 mm. Left valve, USNM 236010; length .61 mm, height .31 mm.

TYPE LOCALITY: Tulane University Department of Geology Locality 201 (see section VIII of this report).

DIMENSIONS: Right valves, length .55-.61 mm; height .29-.33 mm; left valves, length .60-.63 mm; height .29-.32 mm.

MATERIAL: Fourteen valves.

REMARKS: This species differs from *Megacythere striata* (Puri, 1953b), by the presence of a distinctly reticulate surface. *Megacythere robusta* Puri, 1960, is similar, but the new species described here can be distinguished by its lack of large scattered normal pore canals, the greater length/height ratio (2), its smaller size and more distinctly reticulate ornamentation. This species is named in honor of Dr. Richard A. Edwards,

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PLATE 3

Figures Page

1. *Paracytheridea* sp. cf. *P. vandenboldi* Puri, left valve
USNM 236039, X100 142
2. *"Aurila" floridana* Benson and Coleman, right valve
USNM 236013, X100 142
3. *Radimella confragosa*? (Edwards), left valve
USNM 236047, X100 144
4. *"Aurila" bellegladensis* Kontrovitz, n. sp., Paratype, right valve
USNM 235997, X100 143
5. *"Aurila" bellegladensis* Kontrovitz, n. sp., Holotype, left valve
USNM 235996, X100 143
6. *Orionina bradyi* van den Bold, left valve
USNM 236036, X100 145
7. *Puriana rugipunctata* (Ulrich and Bassler), left valve
USNM 236046, X100 147
8. *Proteoconcha multipunctata* (Edwards), right valve
USNM 236044, X100 145

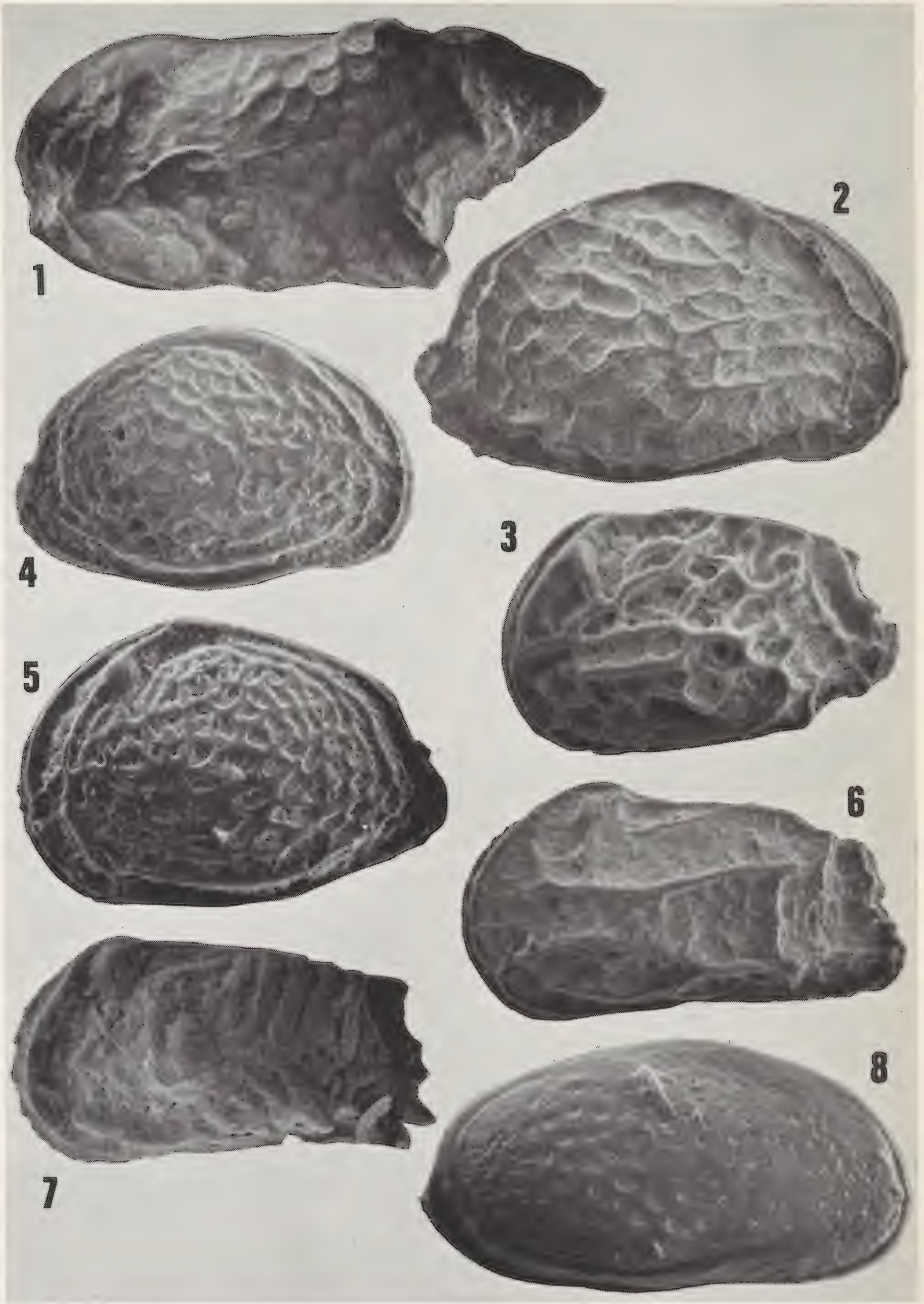

PLATE 3

University of Florida, who introduced the writer to the study of micropaleontology.

Subfamily CYTHEROMATINAE
Elofson, 1939
Genus PELLUCISTOMA
Coryell and Fields, 1937
PELLUCISTOMA sp. aff. P. ATKINSI
Hall, 1965
Plate 4, figure 7

DIMENSIONS: Left valve, length .56 mm; height .29 mm.

MATERIAL: Sixteen valves, of which 11 are juveniles.

REMARKS: The external outline and most of the internal features of this species are similar to those of *P. atkinsi* Hall, 1965. The latter differs by having obviously branching radial pore canals and in being smaller than the species reported here.

Family TRACHYLEBERIDIDAE
Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE
Sylvester-Bradley, 1948
Genus ACTINOCYTHEREIS Puri, 1953
ACTINOCYTHEREIS TRIANGULARIS
Morales, 1966
Plate 4, figure 10

Actinocythereis cf. *A. exanthemata* (Ulrich and Bassler). CURTIS, 1960, p. 478, pl. 3, fig. 10 (not *Cythere exanthemata* Ulrich and Bassler, 1904, p. 117-118, pl. 36, figs. 1-5).

Actinocythereis sp. aff. *A. exanthemata* (Ulrich and Bassler). BENSON and COLEMAN, 1963, p. 48, pl. 6, fig. 12, text figs. 31a-d.

Actinocythereis triangularis MORALES, 1966, p. 80-81, 83, pl. 8, figs. 1a-d.

DIMENSIONS: Carapace, ? female, length .75 mm; height .40 mm; width .38 mm.

MATERIAL: Two carapaces, 13 valves.

REMARKS: These specimens are larger than those described by Morales (1966) from the southeast coast of Mexico; the size is similar to those from the west coast of Florida (Benson and Coleman, 1963). The radial pore canals are slightly curved at the anterodorsal and anteroventral margins in these valves. This species differs from *Actinocythereis vandenboldi* Kontrovitz, 1976, by its rounded, not pointed posterior and its less distinct ornamentation that is arranged in a different pattern.

ENVIRONMENT: Previously reported from modern sediments deposited in shallow brackish and marine waters; subtropical and tropical.

Genus NEOCAUDITES Puri, 1960

PLATE 4

Figures Page

1. *Loxoconcha* sp. cf. *L. matagordensis* Swain, carapace, left valve
   USNM 236029, X100 146
2. *Loxoconcha* sp. cf. *L. sarasotana* Benson and Coleman, right valve
   USNM 236030, X100 145
3. *Loxocorniculum fischeri* (Brady), left valve
   USNM 236031, X100 146
4. *Loxocorniculum postdorsolatum* (Puri), left valve
   USNM 236032, X100 146
5. *Megacythere edwardsi* Kontrovitz, n. sp., Paratype, right valve
   USNM 236007, X100 150
6. *Megacythere edwardsi* Kontrovitz, n. sp., Holotype, left valve
   USNM 236006, X100 150
7. *Pellucistoma* sp. aff. *P. atkinsi* Hall, left valve
   USNM 236042, X100 152
8. *Neocaudites* sp. cf. *N. triplistriata* (Edwards), left valve
   USNM 236034, X100 154
9. *Cytheromorpha paracastanea* (Swain), left valve
   USNM 236027, X100 148
10. *Actinocythereis triangularis* Morales, right valve
    USNM 236011, X100 152

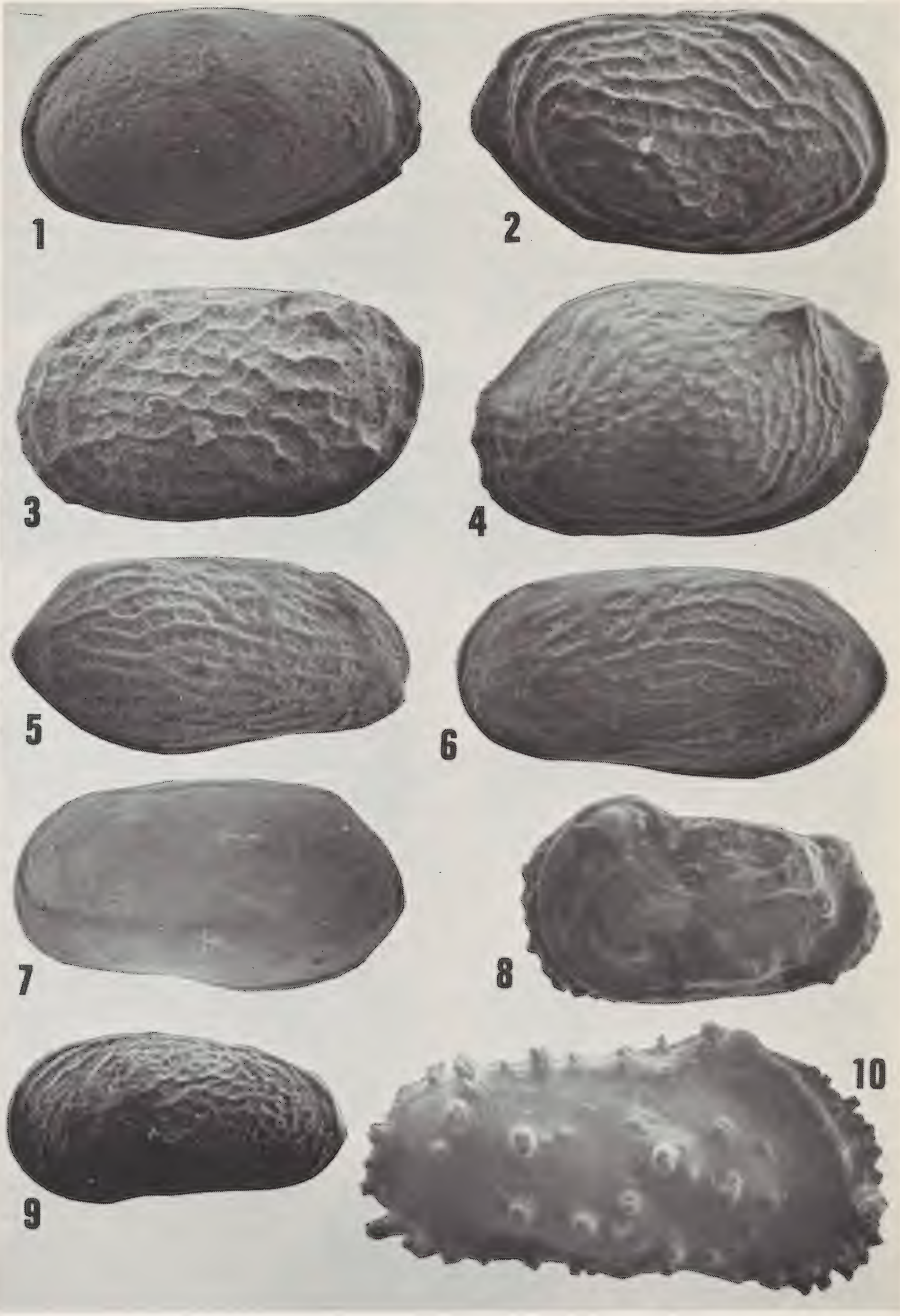

PLATE 4

NEOCAUDITES sp. cf. N. TRIPLISTRIATA
(Edwards, 1944)
Plate 4, figure 8

cf. *Cythereis triplistriata* EDWARDS, 1944, p. 522, pl. 87, figs. 24-26.

Neocaudites triplistricata (Edwards). VAN DEN BOLD, 1963b, p. 389, pl. 8, fig. 4 (with synonymy). SWAIN, 1968, p. D16, pl. 3, figs. 1a-d; text fig. 14. VALENTINE, 1971, p. D8.

DIMENSIONS: Left valve, length .51 mm; height .28 mm.

MATERIAL: Two valves.

REMARKS: There has been some confusion as to the identification of *N. triplistriata* (Edwards, 1944) and *N. nevianii* (Puri, 1960); see van den Bold (1963b), Morales (1966) and Swain (1968). The specimens reported here each have lateral ridges that are not joined at the posterior, therefore this form is not *N. nevianii.*

Subfamily CYTHERETTINAE Triebel, 1952
Genus PROTOCYTHERETTA Puri, 1958
PROTOCYTHERETTA PUMICOSA
(Brady, 1866)
Plate 5, figure 1

Cythere pumicosa BRADY, 1866, p. 379, pl. 61, figs. 3a-c.

Cythere danaiana BRADY, 1869, p. 124, pl. 14, figs. 13, 14. *Not* CURTIS, 1960, p. 478, pl. 2 (top), fig. 2.

Paracytheretta daniana (sic) (Brady). PURI, 1952, p. 210, pl. 40, figs. 10, 11; text fig. 11.

Cytheretta daniana (sic) (Brady). PURI and HULINGS, 1957, p. 174, 187, fig. 11. HULINGS, 1966, p. 46, fig. 6b. HULINGS, 1967, p. 642, fig. 3.

Protocytheretta daniana (sic) (Brady). PURI, 1958b, p. 188, pl. 3, figs. 7-11. PURI, 1960, p. 111, pl. 1, figs. 1, 2; text figs. 18, 19. BENSON and COLEMAN, 1963, p. 26-27, pl. 5, figs. 5, 7, 9, 10; text fig. 13.

Protocytheretta danaiana Brady. HAZEL, 1975, p. 478, 481. VALENTINE, 1971, p. D8.

DIMENSIONS: Left valve, length .96 mm; height .53 mm.

MATERIAL: Six valves and three juvenile valves.

REMARKS: Van den Bold (1971, personal communication) has indicated that *Protocytheretta pumicosa* (Brady, 1866) is a senior synonym of *P. danaiana* (Brady, 1869).

ENVIRONMENT: Previously reported from modern sediments occurring from near the shoreline to water depths of about 152.4 meters; marine; mild temperate, subtropical and tropical.

? Subfamily
Genus BASSLERITES Howe, 1937
BASSLERITES sp.
Plate 5, figure 7

DIMENSTIONS: Carapace, ? female, length .39 mm; height .20 mm; width .16 mm.

MATERIAL: One carapace, two damaged valves.

REMARKS: Exact identification is not possible with these specimens. This form is similar to *Basslerites minutus* van den Bold, 1958b, but differs by having a more rounded posterior cardinal angle in the left valve; the shape of the posterolateral depressions is

PLATE 5

Figures Page
1. *Protocytheretta pumicosa* (Brady), left valve
USNM 236045, X60 154
2. *Physocypria* sp. cf. *P. pustulosa* (Sharpe), right valve
USNM 236043, X100 155
3. *Limnocythere* sp., right valve
USNM 236028, X100 156
4. *Xestoleberis rigbyi* Morales, left valve
USNM 236048, X100 155
5. *Cytherella* sp., left valve
USNM 236018, X100 156
6. *Cytherelloidea* sp. aff. *C. leonensis* Howe, right valve
USNM 236019, X100 156
7. *Basslerites* sp., carapace, left view
USNM 236015, X100 154

also different. This species differs from *B. miocenica* (Howe, 1935) by its size and shape and from *B. vokesi* Kontrovitz, 1976, by its less convex dorsal and ventral outlines.

Family XESTOLEBERIDIDAE Sars, 1928
Genus XESTOLEBERIS Sars, 1866
XESTOLEBERIS RIGBYI Morales, 1966
Plate 5, figure 4

Xestoleberis rigbyi MORALES, 1966, p. 87, 89, pl. 8, figs. 4a-d.

DIMENSIONS: Left valve, length .55 mm; height .36 mm.

MATERIAL: One carapace and 18 valves.

ENVIRONMENT: Previously reported from modern sediments deposited at water depths less than 5.5 meters; brackish and marine; tropical.

Family CYCLOCYPRIDIDAE Kaufman, 1900
Genus PHYSOCYPRIA Várva, 1898
PHYSOCYPRIA sp. cf. P. PUSTULOSA (Sharpe, 1897)
Plate 5, figure 2

cf. *Cypria pustulosa* SHARPE, 1897, p. 461-462.
Physocypria pustulosa (Sharpe). SWAIN, 1955, p. 610, pl. 60, figs. 5a, b (with synonymy).

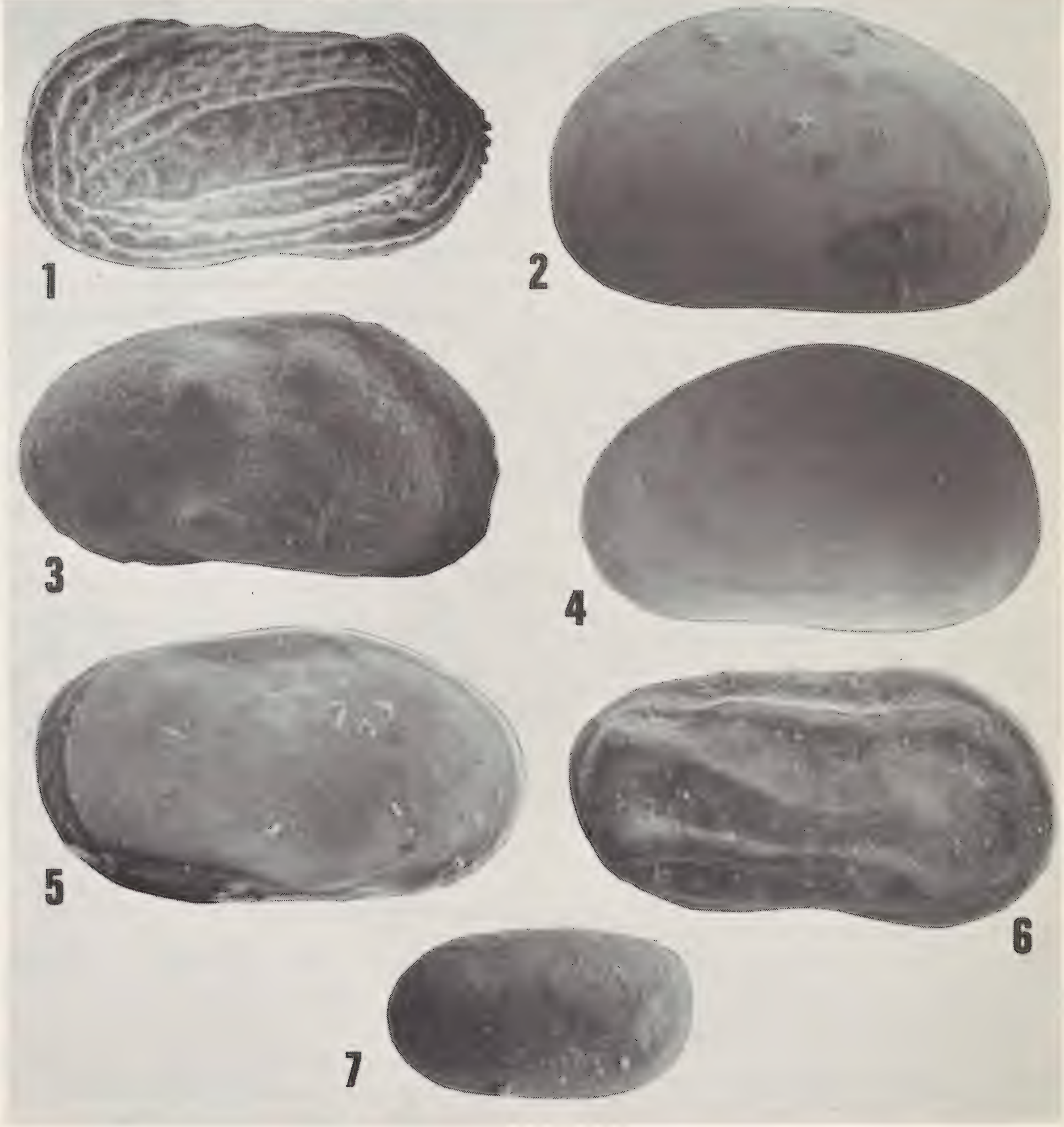

PLATE 5

DIMENSIONS: Carapace, ? female, length .58 mm; height .40 mm; width .30 mm.

MATERIAL: Two carapaces, five valves.

REMARKS: This species is somewhat similar to *Physocypria fadeewi* Dubowski, 1927, as reported by Furtos (1936), but differs by having a more narrow inner lamella and in being more compressed in dorsal view.

ENVIRONMENT: Previously reported from fresh water bodies and from brackish water in the upper portion of San Antonio Bay, Texas (Swain, 1955). Species of this genus have been reported as living only in fresh water (Swain, 1961; Van Morkhoven, 1963).

Family LIMNOCYTHERIDAE Klie, 1938

Genus LIMNOCYTHERE Brady, 1868

LIMNOCYTHERE sp.

Plate 5, figure 3

? *Limnocythere* sp. PURI and VANSTRUM, p. 26, fig. 2.

? *Limnocythere* ? sanctipatricii Brady and Robertson. KEYSER, 1975, p. 490, text fig. 3 (not *Limnocythere sancti-patricii* Brady and Robertson, 1969, p. 17, pl. 18, figs. 8-11; pl. 21, fig. 4).

DESCRIPTION: Moderately calcified, medium size. Right valve, lateral view, trapezoidal, sloping toward posterior; greatest height at anterior cardinal angle. Dorsal margin, straight and sloping toward posterior; ventral margin slightly concave. Anterior margin broadly rounded, posterior more acutely rounded.

Surface: Faintly pitted with a sub-vertical sulcus just in front of mid-length; two nodes, one above the other, just behind mid-length. Lower node gives an alate appearance to valve. Behind lower node, a deep sulcus from ventral margin to mid-height.

DIMENSIONS: Right valve, ? female, length .60 mm; height .34 mm.

MATERIAL: Twenty-three valves.

REMARKS: This species differs from *Limnocythere sanctipatricii* Brady and Robertson, 1869, by being less coarsely pitted, less elongate and by being larger. The specimens are poorly preserved, thus, a complete description is not possible.

ENVIRONMENT: Probably the form reported from the mangrove swamps of southwestern Florida (Keyser, 1975).

Suborder PLATYCOPINA Sars, 1866

Family CYTHERELLIDAE Sars, 1866

Genus CYTHERELLA Jones, 1849

CYTHERELLA sp.

Plate 5, figure 5

DESCRIPTION: Left valve, lateral view, short. Dorsal margin, straight at anterior, sloping behind mid-length. Ventral margin, slightly concave at middle. Anterior margin, broadly rounded; posterior more narrowly rounded. Surface, smooth. Internal features normal for genus.

DIMENSIONS: Left valve, length .57 mm; height .34 mm.

MATERIAL: Seven valves.

REMARKS: The few specimens are insufficient for establishing the identity of this form at the species level.

Genus CYTHERELLOIDEA Alexander, 1929

CYTHERELLOIDEA sp. aff. C. LEONENSIS Howe, 1934

Plate 5, figure 6

DIMENSIONS: Carapace, length .65mm; height .35 mm; width .26 mm.

MATERIAL: One carapace and six valves.

REMARKS: The ornamentation on this form differs from *C. leonensis* Howe, 1934, by being more subdued and in having the dorsal rib flexed inward at about one-third of the length from the anterior. The outline of the carapace is similar to Howe's species.

VIII. LOCALITY DATA

The following are Tulane University fossil locality numbers:

201, "Bermont Formation," pit just south of Belle Glade, Palm Beach Co., Florida.

580, "Bermont Formation," North New River Canal spoil banks, one mile south of South Bay, Palm Beach Co., Florida.

733, "Bermont Formation," North New River Canal spoil banks, one mile north of Florida Highway 80, at South Bay, Palm Beach Co., Florida.

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REVIEWS

MOLLUSCA OF THE MOODYS BRANCH FORMATION, MISSISSIPPI, by David T. Dockery III. Published by the Mississippi Geological, Economic and Topographical Survey, Jackson, Mississippi, Bulletin 120, 1977, 212 pp., 10 figs., 28 pls., index, $6.00

The Moodys Branch Formation forms the basal part of the Jackson Group (upper Eocene) and consists of fossiliferous, glauconitic sands, calcareous clays, and some limestones. The Moodys Branch Formation underlies the Yazoo Clay into which it grades upwards. The Jackson Group and its well-known fauna has been the subject of many significant studies since 1856 when Timothy A. Conrad described and subdivided the Eocene beds of the Gulf Coast Area. Among these are W. H. Dall (1890, 1898, 1900, and 1903), C. Wythe Cooke (1918), and Gilbert D. Harris and Katherine V. W. Palmer (1946, 1947). In this Study by David Dockery, 265 molluscan species or subspecies are reported, of which 213 are illustrated, and 20 are new taxa. The text is illustrated with 28 plates containing 490 figures, some illustrating the original color pattern remnants under ultraviolet light radiation. The systematic study, quite obviously, is most definitive.

In addition, the depositional environment of the Moodys Branch Formation is described in detail. The Moodys Branch molluscs lived in shallow marine waters near a retrograde shoreline. The encroaching shoreline of the transgressive Jackson sea is described as a marine destructional phase of subsiding delta systems in the underlying Claiborne Group. The climate is interpreted as tropical or subtropical, based on the species of molluscs identified, and their diversity. Three faunal provinces are recognized, and cross-sections illustrating the author's analysis of depositional environments are presented. The stratigraphy of the Northern Terrigenous Facies, the Southern Terrigenous Facies, and the Southern Carbonate Facies as recognized within the Moodys Branch section is described fully. This is a most significant contribution to the knowledge of Eocene stratigraphy. The author is nearing completion of his doctoral dissertation on the bivalves of the Vicksburg Group (lower Oligocene) at Tulane University of Louisiana.

MOLLUSCAN Assemblages of the Mid–Holocene New Orleans Barrier Trend, by Eileen E. Hollander, and David T. Dockery III. Published by Sigma Gamma Epsilon: *The Compass,* vol. 55, no. 1 (Fall, 1977), pp. 1-29, 2 figs., 1 table, 8 pls., $3.00 ($8.00 per annum); available through the Oklahoma Geological Survey, Norman, Oklahoma.

Dredging activity for the deepening of the Intracoastal Waterway in eastern Orleans Parish, Louisiana, exposed a marine molluscan assemblage in the dredged material from a depth of 27 meters below the present surface. The source of these molluscs is from buried barrier sands which have been engulfed by the terrigenous clastics of the St. Bernard Delta Complex (c. 3000 to 2600 years B.P.). Two distinct ridge trends have been dated previously, 1) the New Orleans trend, 5100-4400 years B.P., and 2) the Bayou Sauvage-Hancock County trend, 3100-2800 years B. P.

The authors have described 43 species of gastropods, 50 bivalves, and 2 scaphopods from the dredging sites, with a few representatives of phyla other than the Mollusca. The environment of this fauna is compared with the shallow shelf environment of the Gulf side of the present Mississippi-Alabama barrier trend. Among the species present are several which indicate nonturbid, deeper marine conditions. The fauna is interpreted as from the Gulf side of the New Orleans barrier trend, in mid-Holocene time approximately 5000-4000 years B.P. Both authors are doctoral candidates preparing dissertations at the Tulane University of Louisiana.

—H.C.S.

AN OLIGOCENE (ORELLAN) SIRENIAN FROM THE BUCATUNNA FORMATION OF ALABAMA

KENNETH WHETSTONE and LARRY D. MARTIN
DEPARTMENT OF SYSTEMATICS AND ECOLOGY AND MUSEUM OF NATURAL HISTORY
UNIVERSITY OF KANSAS, LAWRENCE, KANSAS

INTRODUCTION

Tertiary sirenians from the New World have been recently reviewed by Reinhart (1976) and Savage (1976). The earliest New World sirenians are known from the presence of pachyostose ribs in Eocene strata of the southeastern United States and from an Eocene skull and mandible from Jamaica. Eocene sirenians have been reported from the Gosport Formation (Bridgerian) of Alabama (Siler, 1964; Russell, 1955) and the Avon Park Limestone (Uintan) of Florida (Reinhart, 1976). The middle Eocene *Prorastomus sirenoides* is based on a single specimen from Jamaica. Several occurrences of Oligocene sirenians have previously been reported in the New World. Two pachyostose ribs were described from Chiapas, Mexico, by Mullerried (1932) and Maldonado (1953). A skull from the middle Oligocene of Puerto Rico was described as *Caribosiren turneri* by Reinhart (1959), and Trelles (1936) noted the occurrence of sirenians in the Oligocene deposits of Cuba. Arata and Jackson (1965) reported sirenians from the Oligocene Red Bluff and Chickasawhay Formations in Mississippi. The age of the Mexican records is uncertain, and Savage (1976) refers to these as "Eocene/Oligocene". The reference by Reinhart (1976, p. 236) to an Oligocene *Halitherium* from Florida is an error; elsewhere in this description these specimens are referred to the Miocene. The specimens described herein, therefore, represent the first Oligocene sirenians reported from Alabama.

In 1973 a field party from the University of Alabama led by D. E. Jones collected the first of the sirenian remains from the Lone Star Cement Quarry on the Tombigbee River 2.2 miles (3.5 km) northeast of St. Stephens, Alabama. Subsequent collections by R. C. Price and K. N. Whetstone produced several additional specimens including the figured portion of a right mandible. The specimens were recovered from the top of the Bucatunna Formation at its upper contact with the Chickasawhay Limestone.

The Bucatunna clay in Alabama and Mississippi is predominantly composed of dark carbonaceous clays and silts. It is locally sandy and bentonitic (Murray, 1961) and is about 25 feet (7.62 m) thick at the Lone Star Quarry (Glawe, 1967). The Bucatunna is middle Oligocene (Orellan) in age and correlates with rocks of Rupelian age in Europe (Cooke *et al.*, 1943). Although the Bucatunna is sometimes grouped with the underlying Byram Marl and Glendon Limestone as the Byram Formation, we have followed Murray (1961) in considering these units to be separate formations.

Fossil vertebrates have not previously been described from Oligocene strata of Alabama, although Cooke (1926, p. 291) noted the occurrence of otoliths in the Byram Marl. The sirenian specimens from the Lone Star Quarry were associated with crocodilian scutes (GSA-V-1085), spines and dental plates of myliobatid rays (GSA-V-1083, 1084), sharks teeth of the genera *Odontaspis, Galeocerdo* and *Isurus* (GSA-V-1089), and vertebrae and otoliths of several teleost fishes. These specimens are catalogued into the collections of the Geological Survey of Alabama (GSA) and the University of Kansas (KUVP).

DESCRIPTION

The specimens reported here include part of a left ramus (KUVP 43130), part of a neural arch (GSA-V-1086), and several ribs (KUVP 43131, GSA-V-1090). They are from a small sirenian with very short pachyostose ribs. The mandible appears to be relatively short and moderately deep. The mandibular canal is large and exits posterior to the last molar just below the anterior edge of the ascending ramus. The portion of the ascending ramus preserved is straight but is not

complete enough to rule out the possibility that it may have inclined forward as in the manatee, *Trichecus*. The four roots preserved on the ramus are probably from two molars. The anterior tooth has two broad, flat roots, while the posterior tooth has a flat anterior root and a round posterior root indicating that this is the last molar. No alveolae occur anterior to the roots preserved on the fragment, and it would appear that only two molars were present.

Very few systematic inferences can be made from such fragmentary material. However, the apparent tooth reduction would suggest that it should not be referred to the Trichechidae. It is also not from a dugong as it possesses rooted teeth and short massive ribs. It might be related to *Hydrodamalis* as this genus is edentulous with very massive dense ribs (Simpson, 1932). Of the fossil taxa, *Metaxytherium* does not show the tooth reduction that appears to be present in the Alabama fossil. At the present time the best assignment that we can make for this material is Dugongidae, genus undetermined. If the tooth reduction suggested here should prove to be real, then a new generic taxon would be required.

ACKNOWLEDGEMENTS

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December 28, 1978

PLATE 1

Oligocene sirenians from the Bucatunna Formation of Alabama. 1. right mandible (KUVP 43130) in lateral (1a.), dorsal (1b.), and medial view (1c.); 2. and 3. ribs (KUVP 43131 and GSA V-1090 respectively). Scale is 2 cm.

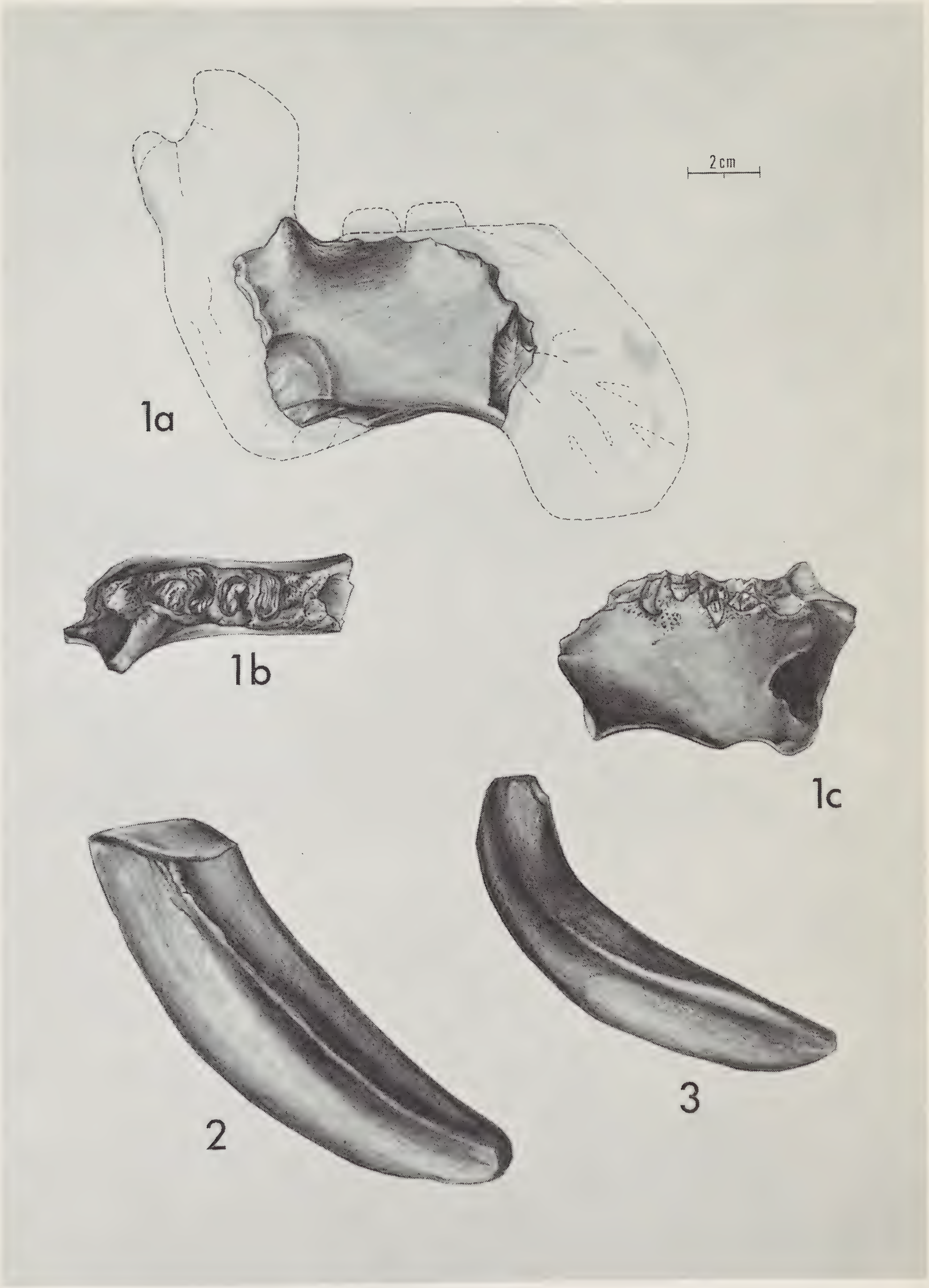

PLATE 1

REVIEWS

GEOLOGY AT M.I.T. 1865-1965: A History of the First Hundred Years of Geology at Massachusetts Institute of Technology, I. The Faculty and Supporting Staff, by Robert R. Shrock. Published by The MIT Press, Cambridge, Massachusetts, and London, England, 1977, xxiv + 1032 pp., illus., $25.00

This is the first of two volumes planned by Professor Shrock to record the role that geologists and geology played at the Massachusetts Institute of Technology during its first century. The present volume, on the geology faculty, consists largely of biographical sketches of the first fifty-three professors of geology at MIT. It includes also an account of the founding of the Institute, the development of the curriculum and faculty in geology, and of visiting and named professors and lecturers who also served at the Institute during 1865-1965. The second volume (nyp) is to be devoted to the activities and accomplishments of the professors and their supporting personnel.

The massive first volume of Professor Shrock's work is at least impressive if not formidable. However, historians of geological education and the friends and graduates of MIT will find the volume most useful as a biographical handbook and reference volume. It is not indexed, but this is hardly necessary due to the nature of the subject and to the detailed table of contents which precedes the text. The attractiveness of the book is marred by the unjustified margins and the unimaginative, though legible, type style. However, the illustrations are numerous and most pleasing and well selected. Especially interesting are the early classroom views and pages from Waldemar Lindgren's class notes taken at the Bergakademie in Freiberg, Saxony. The book is well bound and the price is surprisingly low for such a large volume.

The biographical accounts are arranged in chronological order, beginning with William Barton Rogers, Founder and first President of the Institute, and first Professor of Physics and Geology, 1865-1881, and continuing to Frank Press, the fifty-third professor, appointed in 1965, as MIT began its second century. In addition to William Barton Rogers, other famed geologists from the MIT roster include Alpheus Hyatt (1870-1888), Thomas Sterry Hunt (1872-1878), Hervey Woodburn Shimer (1903-1965), Reginald Aldworth Daly (1907-1915), Waldemar Lindgren (1908-1939), Frederic Henry Lahee (1912-1918), Robert Rakes Shrock (1937-1975), and Louis Herman Ahrens (1948-1963).

MODERN QUATERNARY RESEARCH IN SOUTHEAST ASIA: volume 3, edited by Gert-Jan Bartstra, Willem Arnold Casparie, and Ian C. Glover. Published by A. A. Balkema, Rotterdam, 1977, ix + 155 pp., illus., $10.50 (distributed in the United States by ISBS, Inc., Forest Grove, Oregon).

In this, the third volume of the series, emphasis is placed on the Holocene Period and the prehistory of Southeast Asia. The five papers include Maritime adaptations and exploitation of marine resources in Sundaic Southeast Asia prehistory, by F. L. and D. F. Dunn; Laang Spean and the prehistory of Cambodia, by Roland Mourer; Phu Wiang pottery and the prehistory of Northeastern Thailand, by D. T. Bayard; The prehistory of the Southern Khorat Plateau, North East Thailand, by C. F. W. Higham; and The height of the river terraces in the transverse Solo valley in Java, by Gert-Jan Bartstra. Only the last paper will be of significant importance to geologists, as it deals with terraces which yielded specimens of early Man in Java.

—H.C.S.

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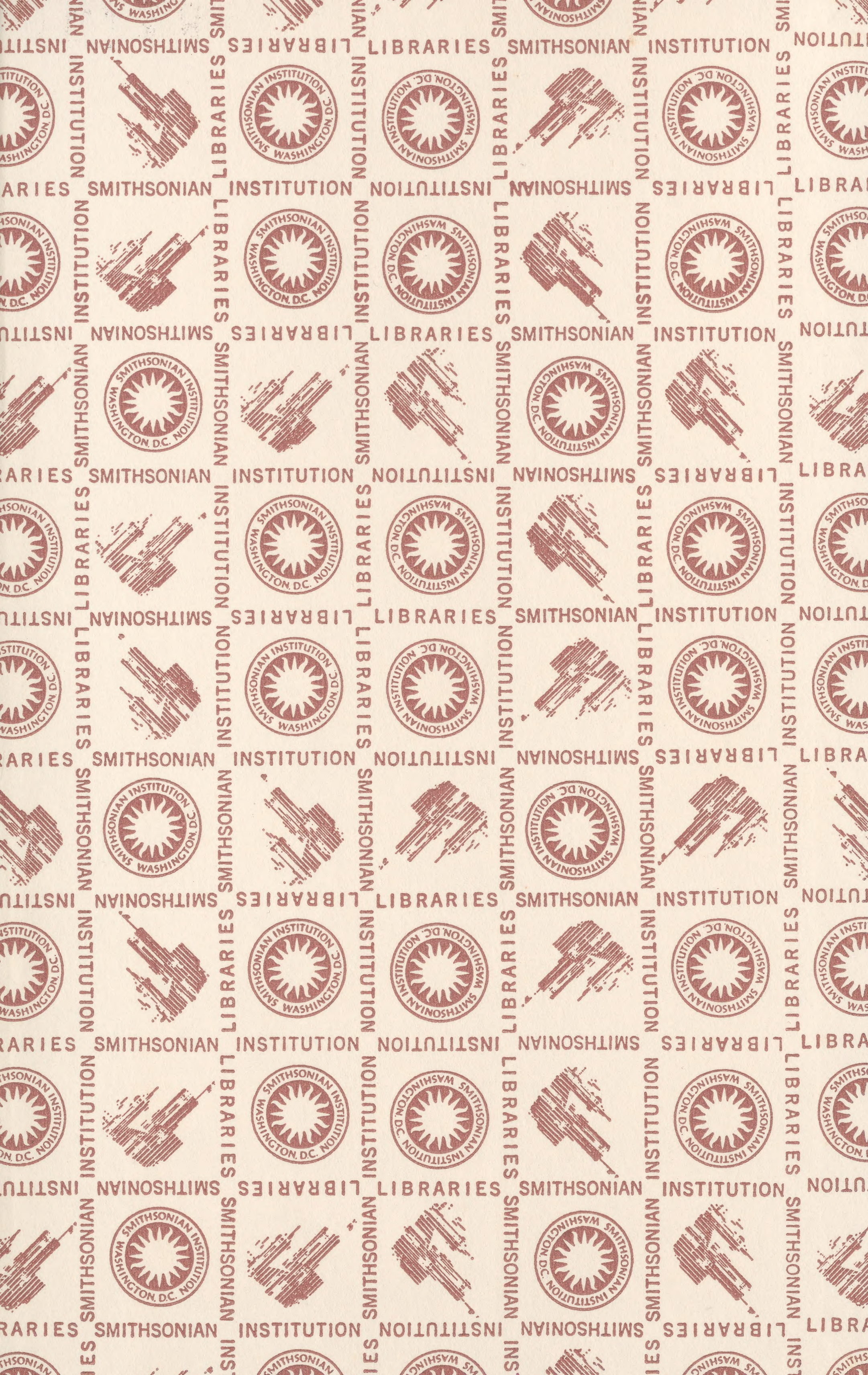
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